In presenting the dissertation as a partial fulfillment of the requirements for an advanced degree from the Georgia Institute of Technology, I agree that the Library of the Institute shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to copy from, or to publish from, this dissertation may be granted by the professor under whose direction it was written, or, in his absence, by the Dean of the Graduate Division when such copying or publication is solely for scholarly purposes and does not involve potential financial gain. It is understood that any copying from, or publication of, this dissertation which involves potential financial gain will not be allowed without written permission.

7/25/68

USE OF THE CLASS OF EQUIRADIAL EXPERIMENTAL DESIGNS

IN RESPONSE SURFACE METHODOLOGY

A THESIS

Presented to

The Faculty of the Division of Graduate

Studies and Research

by

Claude K. Hudson

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in the School of Industrial and Systems Engineering

Georgia Institute of Technology

August, 1972

USE OF THE CLASS OF EQUIRADIAL EXPERIMENTAL DESIGNS

IN RESPONSE SURFACE METHODOLOGY

Approved:

Douglas C. Montgomery, Chairman

Leslie G. Callahan

Russell G. Heikes

Date approved by Chairman: Aug 24, 1972

ACKNOWLEDGMENTS

The author wishes to express his sincere gratitude to his thesis advisor, Dr. Douglas C. Montgomery, for the invaluable guidance, encouragement, and constructive criticism which made the successful completion of this research possible.

The author is also deeply indebted to Drs. Leslie G. Callahan and Russell G. Heikes for their advice and encouragement as members of the thesis committee.

Special appreciation is extended to Mr. Michael Deisenroth for his valuable assistance in computer programming and his cheerful companionship during many moments of electronic frustration.

Appreciation is also due to Mrs. Lydia Geeslin for her skillful assistance in the preparation of this manuscript.

A very special "thank you" is given to the author's children, Kevin and Katie, for their love and contagious enthusiasm, and to his wife, Karen, for her love, encouragement, support, and companionship throughout two years of graduate study and during the preparation of this thesis.

These acknowledgments would be incomplete without an expression of gratitude to the United States Army for sending the author through these two years of graduate study.

Finally, to Mrs. Lucile C. Hussey, mathematician, educator, and mother, this work is lovingly dedicated.

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

LIST OF TABLES

LIST OF ILLUSTRATIONS

SUMMARY

This thesis presents a study of the class of equiradial experimental designs for use in response surface methodology. The research surveys the field of response surface methodology and the use of second order experimental designs in fitting and optimizing response surfaces.

The construction of second order experimental designs is studied, with particular emphasis on the class of equiradial designs. The concept of rotatability and other design criteria are developed and illustrated in the construction of equiradial designs.

A representative selection of two factor equiradial designs is constructed and applied to a variety of known response surfaces under various controlled conditions. A similar application is made of several standard central composite designs. The results for all of these designs are collected into several logical groups for analysis. Conclusions drawn from this analysis are that the best performance is provided by those equiradial designs derived from equiradial pentagons and hexagons, in particular, by uniform precision designs so derived. Pentagon and hexagon derived designs are also seen to generally outperform central composite designs.

CHAPTER I

INTRODUCTION

1.1 Response Surface Methodology

Response surface methodology is a collection of mathematical and statistical techniques first produced by Box and Wilson (4). The goal of response surface methodology is to find the optimum of a response y, where

$$y = \phi(x_1, x_2, \ldots, x_k) \tag{1.1}$$

is a function of several variables x_1, x_2, ..., x_k. The true functional relationship ϕ is unknown and successive observations on y are obscured by random error.

In general, response surface methodology approximates the relationship (1.1) by a regression model of the form

$$y = \underline{x}'\underline{\beta} + \epsilon \ , \tag{1.2}$$

where $\underline{x}$ is a vector of the independent variables, $\underline{\beta}$ is a vector of regression coefficients, and ϵ is the random error associated with the observation on y. The procedure is sequential in nature, usually first applying a linear regression model to fit a first order response equation (surface) until a lack of fit is detected and then fitting a higher order response surface, usually of second order. The form of the approximating function is usually a polynomial such as

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + \epsilon \qquad (1.3)$$

for the first order approximation, and

$$y = \beta_0 + \sum_i \beta_i x_i + \sum_i \beta_{ii} x_i^2 + \sum_{\substack{i \\ i<j}} \sum_j \beta_{ij} x_i x_j + \epsilon \qquad (1.4)$$

for the second order approximation.

Fitting a second order regression model requires the use of a second order experimental design. The most widely known and used classes of second order experimental designs are factorial and central composite designs. Another, less widely used, class of second order experimental designs is the equiradial class. By far, the majority of studies on construction and performance of second order experimental designs have dealt primarily with central composite designs. The purpose of this study is to investigate the class of second order equiradial designs.

1.2 Objectives

The objectives of this thesis are:

1. To investigate the properties, construction, and use of the class of equiradial designs.

2. To analyze the effectiveness of designs from this class in comparison to central composite designs.

3. To draw conclusions regarding this class of designs.

These objectives will be accomplished by surveying response surface methodology and second order experimental designs, with particular attention to the class of equiradial designs. A representative group of equiradial designs will then be constructed and applied to several known response surfaces under various controlled conditions. Central composite designs will be applied in the same manner. The results will then be compared and evaluated, and conclusions will be drawn.

1.3 Assumptions

The following assumptions are made:

1. In the testing of various designs on the surfaces to be discussed later, it is assumed that a region has already been encountered where there is a "lack of fit" for the first order model. At this point, fitting of a second order model is deemed appropriate.

2. The equiradial designs from pentagon (5 vertices) to decagon (10 vertices) inclusive are selected as representative of the class of equiradial designs.

CHAPTER II

RESPONSE SURFACE METHODOLOGY

2.1 General

Response surface methodology seeks to optimize a response by approximating the unknown functional relationship between the response and its independent variables and then optimizing the approximating function. This approximation makes use of the general linear regression model

$$\underline{y} = X \, \underline{\beta} + \underline{\epsilon} \, , \tag{2.1}$$

where $\underline{y}$ is a vector of response observations, X is a matrix in which the i^{th} row represents the levels of the independent variables associated with the i^{th} response observation, $\underline{\beta}$ is the vector of regression coefficients, and $\underline{\epsilon}$ is a vector in which the i^{th} element represents the random error associated with the i^{th} observed response. In general, $\underline{y}$ is $(N \times 1)$, X is $(N \times p)$, $\underline{\beta}$ is $(p \times 1)$, and ϵ is $(N \times 1)$.

It should be noted that this model is linear only in the β's and is therefore applicable to any order response surface. Consider the first order response model

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \epsilon \; . \tag{2.2}$$

Here the $\underline{\beta}$ vector is

$$\underline{\beta}' = [\beta_0, \beta_1, \ldots, \beta_k] ,$$

and a typical row of the X matrix is

$$\underline{x}_i = [1, x_{i1}, \ldots, x_{ik}] .$$

The second order response model is

$$y = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_i^2 + \sum_{i<j}\sum \beta_{ij} x_i x_j + \epsilon . \tag{2.3}$$

In this case the $\underline{\beta}$ vector is

$$\underline{\beta}' = [\beta_0, \beta_1, \ldots, \beta_k, \beta_{11}, \ldots, \beta_{kk}, \beta_{12}, \ldots, \beta_{(k-1)k}] ,$$

and a typical row of the X matrix is

$$\underline{x}_i = [1, x_{i1}, \ldots, x_{ik}, x_{i1}^2, \ldots, x_{ik}^2, x_{i1}x_{i2}, \ldots, x_{i(k-1)}x_{ik}] .$$

In fitting the model we wish to estimate the $\underline{\beta}$ vector in such a manner as to minimize the sum of squares of the error. Our problem then is

$$\min L = \min \sum_{i=1}^{k} \epsilon_i^2 = \min \underline{\epsilon}'\underline{\epsilon} \tag{2.4}$$

Solving equation (2.1) for $\underline{\epsilon}$ gives

$$\underline{\epsilon} = \underline{y} - X\underline{\beta} . \tag{2.5}$$

Substituting equation (2.5) into equation (2.4) and simplifying yields

$$\min L = \min \, [\underline{y}'\underline{y} - 2\underline{\beta}' \, X \, \underline{y} + \underline{\beta}' \, X'X \, \underline{\beta}] \ .$$

Taking the partial derivative of L with respect to $\underline{\beta}$ and setting it equal to zero yields

$$\frac{\partial L}{\partial \underline{\beta}} = - \, 2X'\underline{y} + 2(X'X)\hat{\underline{\beta}} = 0 \ .$$

Solving this for $\hat{\underline{\beta}}$ provides the least squares estimator of $\underline{\beta}$,

$$\hat{\underline{\beta}} = (X'X)^{-1} \, X'\underline{y} \ . \qquad (2.6)$$

A response surface analysis usually begins with a first order investigation and proceeds in this manner until a lack of fit is encountered and a near optimum condition is suspected.

Numerous first order optimization methods are available. Among the most commonly used methods are steepest ascent, univariate, factorial, and random search. The steepest ascent and univariate are sequential search methods. As its name implies, the steepest ascent method determines the steepest gradient in a small region and ascends in that direction until another gradient determination is necessary. In the univariate method, one factor at a time is varied over the region of interest while all others are held constant. This is repeated until no further improvement in response is achieved. The factorial method uses a single factorial experiment for the entire region of interest. In the random method, trials are made at random throughout the region of interest.

Brooks (5) made a comparative study of these four first order methods. He tested each method on the four surfaces shown in Figures 1(a) through 1(d). The results of his study indicated that the sequential methods performed best and that the steepest ascent method performed better than the univariate method, on the average.

2.2 Second Order Investigation

Consider the second order fitted response model

$$\hat{y} = \hat{\beta}_0 + \sum_{i=1}^{k} \hat{\beta}_i x_i + \sum_{i=1}^{k} \hat{\beta}_{ii} x_i^2 + \sum_{i<j}\sum \hat{\beta}_{ij} x_i x_j \ .$$

This may be rewritten in matrix form as

$$\hat{y} = b_0 + \underline{x}'\underline{b} + \underline{x}'B\,\underline{x} \ , \tag{2.7}$$

where

$$\underline{x}' = [x_1, x_2, \ldots, x_k] \ ,$$
$$b_0 = \hat{\beta}_0 \ ,$$
$$\underline{b}' = [\hat{\beta}_1, \hat{\beta}_2, \ldots, \hat{\beta}_k] \ ,$$

and

$$B = \begin{bmatrix} \hat{\beta}_{11} & \frac{1}{2}\hat{\beta}_{12} & \cdots & \frac{1}{2}\hat{\beta}_{1k} \\ (\text{symmetric}) & \hat{\beta}_{22} & \cdots & \frac{1}{2}\hat{\beta}_{2k} \\ & & \cdots & \cdots \\ & & & \hat{\beta}_{kk} \end{bmatrix} .$$

To find the factor combination which optimizes y we differentiate equation (2.7) with respect to $\underline{x}$ and set the results equal to zero. This yields

$$\frac{\partial y}{\partial \underline{x}} = \underline{b} + 2B\underline{x} = 0 \ ,$$

or

$$\underline{x}_0 = -\tfrac{1}{2}B^{-1}\underline{b} \ , \tag{2.8}$$

the estimated point of optimum response. Substituting equation (2.8) into equation (2.7) and simplifying gives the predicted optimum response:

$$y_0 = b_0 + \tfrac{1}{2}\underline{x}_0'\underline{b} \tag{2.9}$$

The stationary point $\underline{x}_0$ is, of course, not necessarily a maximum. In fact it may be either a maximum, a minimum, or a saddle point. To determine the nature of the surface at the stationary point one must conduct a canonical analysis. The canonical analysis translates the variable axes to the stationary point and then rotates the axes to correspond to the principal axes of the contour system. Substituting the transformation $\underline{z} = \underline{x} - \underline{x}_0$ into equation (2.7) and simplifying yields

$$\hat{y} = \hat{y}_0 + \underline{z}'B\underline{z} \ , \tag{2.10}$$

the response in terms of the $\underline{z}$ variables. This accomplishes the translation of the axes to the stationary point. Setting $\underline{z} = M\underline{w}$, equation (2.10) may be expressed as

$$y = y_0 + \underline{w}'M'BM\underline{w} = y_0 + \sum_{i=1}^{k} \lambda_i w_i^2 \ , \tag{2.11}$$

where $\underline{w}$ represents the principal axes of the contour system, M is the orthogonal transform of $\underline{w}$ onto $\underline{z}$, and

$$M'BM = \begin{bmatrix} \lambda_1 & & & \\ & \lambda_2 & & 0 \\ & & \ddots & \\ & 0 & & \lambda_k \end{bmatrix}$$

where the λ_i are the eigenvalues of the matrix B.

Inspection of the λ_i's will reveal the nature of the surface at the stationary point. From equation (2.11) it is clear that, if all λ_i are negative, then a move along any w axis away from the stationary point (origin of the w axes) will reduce the response, and hence we have a maximum. Similarly, if all λ_i are positive we have a minimum, and if the λ_i have mixed signs we have a saddle point.

2.3 Selection Criteria for Second Order Designs

In order to conduct a second order analysis, a second order experimental design must be used to estimate the model parameters. Several performance criteria have been developed for the selection of response surface designs. These will be discussed in this section, but first it is useful to introduce the concepts of design moments and precision.

2.3.1 Design Moments and Precision

The design moments are expressed in terms of the levels of the design variables. Consider the design matrix

$$D = \begin{bmatrix} x_{11} & \cdots & x_{k1} \\ \cdots & \cdots & \cdots \\ x_{1N} & \cdots & x_{kN} \end{bmatrix}$$

where the i^{th} row represents the variable levels to be set for the i^{th} observation. In general the design moments are

$$[1^{\alpha 1}\ 2^{\alpha 2} \ldots k^{\alpha k}] = \frac{1}{N} \sum_{u=1}^{N} x_{1u}^{\alpha 1}\, x_{2u}^{\alpha 2} \ldots x_{ku}^{\alpha k} . \tag{2.12}$$

The order of the moment is equal to the sum of the α_i's. The moment is even if all α_i's are even and odd if any α_i is odd. If only one α_i is nonzero, then the moment is said to be a pure moment, otherwise it is mixed.

The moments of a d^{th} order experimental design are of order through 2d. Hence a second order design will have design moments of order through four. These include the second pure moment

$$[ii] = \frac{1}{N} \sum_{u=1}^{N} x_{iu}^{2} , \tag{2.13}$$

the fourth pure moment

$$[iiii] = \frac{1}{N} \sum_{u=1}^{N} x_{iu}^{4} , \tag{2.14}$$

and the fourth mixed even moment

$$[iijj] = \frac{1}{N} \sum_{u=1}^{N} x_{iu}^{2}\, x_{ju}^{2} . \tag{2.15}$$

The moment matrix for an experimental design is defined as $N^{-1}(X'X)$. For example, a second order design in two variables (k=2) has moment matrix

$$N^{-1}(X'X) = \begin{bmatrix} 1 & [1] & [2] & [11] & [22] & [12] \\ & [11] & [12] & [111] & [122] & [112] \\ & & [22] & [112] & [222] & [122] \\ & \text{(symmetric)} & & [1111] & [1122] & [1112] \\ & & & & [2222] & [1222] \\ & & & & & [1122] \end{bmatrix} \tag{2.16}$$

The inverse of the moment matrix, that is $N(X'X)^{-1}$, is called the precision matrix. The elements of the precision matrix represent the variances and covariances associated with the estimators of the model parameters produced by the design. For a second order experimental design in two variables this is

$$N(X'X)^{-1} = \frac{N}{\sigma^2}\begin{bmatrix} Var(b_0) & Cov(b_0b_1) & Cov(b_0b_2) & Cov(b_0b_{11}) & Cov(b_0b_{22}) & Cov(b_0b_{12}) \\ & Var(b_1) & Cov(b_1b_2) & Cov(b_1b_{11}) & Cov(b_1b_{22}) & Cov(b_1b_{12}) \\ & & Var(b_2) & Cov(b_2b_{11}) & Cov(b_2b_{22}) & Cov(b_2b_{12}) \\ & \text{(symmetric)} & & Var(b_{11}) & Cov(b_{11}b_{22}) & Cov(b_{11}b_{12}) \\ & & & & Var(b_{22}) & Cov(b_{22}b_{12}) \\ & & & & & Var(b_{12}) \end{bmatrix} \tag{2.17}$$

The precision matrix and design moments are important concepts in the development of design criteria.

2.3.2 Rotatability

Box and Hunter (3) suggested that a desirable characteristic for a response surface design is that $\mathrm{Var}(\hat{y})$, the variance of the fitted response surface, be a function of distance from the design center alone and not of direction from the design center. That is, the design should produce variance contours which are hyperspheres, and hence the variance of the fitted surface is unaffected by the orientation of the design about any given design center. Box and Hunter called this design characteristic rotatability, and developed a necessary and sufficient condition for a rotatable design.

A design of order d is rotatable if and only if for all moments of order through 2d

$$[1^{\alpha 1}\quad 2^{\alpha 2}\quad \ldots \quad k^{\alpha k}] = \frac{\lambda_\alpha \prod_{i=1}^{k} (\alpha_i)!}{2^{\alpha/2} \prod_{i=1}^{k} \left(\frac{\alpha_i}{2}\right)!} \tag{2.18}$$

if all α_i are even, and

$$[1^{\alpha 1}\quad 2^{\alpha 2}\quad \ldots \quad k^{\alpha k}] = 0 \ , \tag{2.19}$$

if any α_i is odd, where $\alpha = \sum_{i=1}^{k} \alpha_i$ is the order of the moment.

For a second order design this condition implies that

$$[11] = \quad [22] = \frac{\lambda_2(2!0!)}{2(1!0!)} = \lambda_2 \ , \tag{2.20}$$

$$[1111] = [2222] = \frac{\lambda_4(4!0!)}{2^2(2!0!)} = 3\lambda_4 \ , \tag{2.21}$$

$$[1122] = [2211] = \frac{\lambda_2(2!2!)}{2^2(1!1!)} = \lambda_4 \ , \tag{2.22}$$

and all other moments (i.e., odd moments) are zero.

The moment matrix for a rotatable second order design, therefore, must be of the form

$$N^{-1}(X'X) = \begin{array}{c@{\;}c}
 & \begin{array}{cccccccccccc} 0 & x_1 & x_2 & \cdots & x_k & x_1^2 & x_2^2 & \cdots & x_k^2 & x_1x_2 & \cdots & x_{k-1}x_k \end{array} \\
\begin{array}{c} 0 \\ x_1 \\ x_2 \\ \vdots \\ x_k \\ x_1^2 \\ x_2^2 \\ \vdots \\ x_k^2 \\ x_1x_2 \\ \vdots \\ x_{k-1}x_k \end{array} &
\left[\begin{array}{c|cccc|cccc|ccc}
1 & 0 & 0 & \cdots & 0 & \lambda_2 & \lambda_2 & \cdots & \lambda_2 & 0 & \cdots & 0 \\ \hline
0 & \lambda_2 & & & & & & & & & & \\
0 & & \lambda_2 & 0 & & & & & & & & \\
\vdots & & & \ddots & & & 0 & & & & 0 & \\
0 & 0 & & & \lambda_2 & & & & & & & \\ \hline
\lambda_2 & & & & & 3\lambda_4 & & & & & & \\
\lambda_2 & & 0 & & & & 3\lambda_4 & 0 & & & 0 & \\
\vdots & & & & & & 0 & \ddots & & & & \\
\lambda_2 & & & & & & & & 3\lambda_4 & & & \\ \hline
0 & & & & & & & & & \lambda_4 & & \\
\vdots & & 0 & & & & 0 & & & & \ddots & 0 \\
0 & & & & & & & & & 0 & & \lambda_4
\end{array}\right]
\end{array}$$

It should be noted at this point that λ_2 is just a "nuisance" parameter altered by the choice of scaling convention. In fact, when a value is selected for λ_2, all designs which have that same λ_2 value are said to be scaled to the same convention. The "usual" scaling convention is $\lambda_2 = 1$.

2.3.3 Other Design Criteria

Consider now the precision matrix. Box and Hunter showed that, for a second order rotatable design under the usual scaling convention, the elements of the precision matrix are

$$\frac{N}{\sigma^2} \operatorname{Var}(b_0) = 2\lambda_4^2 \, (k+2)A \tag{2.23}$$

$$\frac{N}{\sigma^2} \operatorname{Var}(b_i) = 1 \tag{2.24}$$

$$\frac{N}{\sigma^2} \operatorname{Var}(b_{ii}) = [(k+1)\lambda_4 - (k-1)]A \tag{2.25}$$

$$\frac{N}{\sigma^2} \operatorname{Var}(b_{ij}) = \lambda_4^{-1} \tag{2.26}$$

$$\frac{N}{\sigma^2} \operatorname{Cov}(b_0, b_{ii}) = -2\lambda_4 A \tag{2.27}$$

and

$$\frac{N}{\sigma^2} \operatorname{Cov}(b_{ii}, b_{ij}) = (1 - \lambda_4)A \, , \tag{2.28}$$

where

$$A = [2\lambda_4\{(k+2)\lambda_4 - k\}]^{-1},$$

and all other covariances are zero.

It is readily observable that $\lambda_4 = 1$ will make $\frac{N}{\sigma^2} \operatorname{Cov}(b_{ii}, b_{jj}) = 0$ and hence give an orthogonal rotatable design. One can also note that, if $\lambda_4 = k/k+2$, then $A = \infty$, and the variances are undefined. This implies a singular (X'X) matrix and hence a design which cannot be used.

Clearly the variances are functions of λ_4. Consider the variance of the fitted response surface, say

$$\frac{N}{\sigma^2} \mathrm{Var}(\hat{y}) = \frac{N}{\sigma^2} \Big[\mathrm{Var}(b_0) + \sum_{i=1}^{k} x_i^2 \mathrm{Var}(b_i) + \sum_{i=1}^{k} x_i^4 \mathrm{Var}(b_{ii}) \qquad (2.29)$$

$$+ \sum_{i<j}\sum x_i^2 x_j^2 \mathrm{Var}(b_{ij}) + 2 \sum_{i=1}^{k} x_i^2 \mathrm{Cov}(b_0, b_{ii}) + 2 \sum_{i<j}\sum x_i^2 x_j^2 \mathrm{Cov}(b_{ii}, b_{jj}) \Big]$$

Substituting equations (2.23) through (2.28) into equation (2.29) and simplifying yields

$$\frac{N}{\sigma^2} \mathrm{Var}(\hat{y}) = A\{2\lambda_4^2 (k+2) + 2\rho^2 \lambda_4(\lambda_4 - 1)(k+2) + \rho^4[(k+1)\lambda_4 - (k-1)]\}$$

where

$$\rho^2 = \sum_{i=1}^{k} x_i^2$$

$\frac{N}{\sigma^2} \mathrm{Var}(\hat{y})$ can now be plotted as a function of ρ for various values of λ_4. Such a graph can be found in Myers (8).

Box and Hunter observed that large values of λ_4 tend to admit heavy biasing if the fitted model is of a lower order than the true response surface, while small values of λ_4 tend to give poor results at $\rho = 0$ and cause $\frac{N}{\sigma^2} \mathrm{Var}(\hat{y})$ to behave poorly for $\rho > 0$. They suggested that λ_4 should be selected so as to make $\frac{N}{\sigma^2} \mathrm{Var}(\hat{y})$ at the design center ($\rho = 0$) equal to $\frac{N}{\sigma^2} \mathrm{Var}(\hat{y})$ at $\rho = 1$. Designs which satisfy this condition are called uniform precision designs. Values of λ_4 which produce second order uniform precision designs for various numbers of factors (k) are given in Table 1.

Table 1. λ_4 Values for Second Order Rotatable Uniform Precision Designs

k	2	3	4	5	6	7
λ_4	0.7844	0.8385	0.8704	0.8918	0.9070	0.9184

The design criteria presented so far have been variance oriented. That is, rotatability is based entirely on variance, and uniform precision, while acknowledging bias effects by avoiding large values of λ_4, is primarily concerned with variance.

Box and Draper (1) discussed the importance of considering bias, that is, the errors in a fitted model due to the true surface being of a higher order than the model. They proposed a criterion which considers both variance and bias. Their criterion is based on integrated mean square error.

Consider the equation

$$J = \frac{NK}{\sigma^2} \int_R E[\hat{y} - g]^2 \, \underline{dx} \tag{2.30}$$

where $\hat{y}$ represents the fitted surface of order d_1, g represents the true surface of order d_2 ($d_2 > d_1$), R is the region of interest, and $K = \left[\int_R d\,\underline{x}\right]^{-1}$. Clearly this represents the mean square error between $\hat{y}$ and g integrated over the region of interest R. Expanding the squared portion of equation (2.30) and taking the expectation of each term gives

$$J = \frac{NK}{\sigma^2} \int_R \left[E(\hat{y}^2) - 2\,gE(\hat{y}) + g^2\right] dx \,. \tag{2.31}$$

It is well known (see Myers (8)) that equation (2.31) can be written as

$$J = \frac{NK}{\sigma^2} \int_R \left\{ [E(\hat{y}^2) - E(\hat{y})^2] + [E(\hat{y})^2 - 2gE(\hat{y}) + g^2] \right\} d\underline{x} \qquad (2.32)$$

or

$$J = V + B \, , \qquad (2.33)$$

where

$$V = \frac{NK}{\sigma^2} \int_R [E(\hat{y}^2) - E(\hat{y})^2] \, d\underline{x}$$

is the integrated variance of $\hat{y}$, and

$$B = \frac{NK}{\sigma^2} \int_R [E(\hat{y}) - g]^2 \, d\underline{x}$$

is the integrated squared bias.

Unfortunately J cannot be directly minimized without knowledge of the coefficients missing from the fitted model. The approach usually followed is to minimize either V or B. Box and Draper called designs which minimize V "all variance" designs and designs which minimize B "all bias" designs.

In a subsequent paper, Box and Draper (2) showed that even if the variance term is eight times the value of the bias term the optimal design which minimizes J is very close to the "all bias" design. They also provided a series of curves which describe the optimal design moments from "all bias" to "all variance" for various numbers of factors. For the second order "all bias" design they found the design moments should be $\lambda_2 = (0.515)^2$ and $3\lambda_4/\lambda_2^2 = 1.887$. These design moments will be used later to construct designs which will minimize the effects of bias.

2.4 Second Order Designs

2.4.1 Equiradial Designs

The class of designs which this thesis will investigate consists of polygon designs such that all points are equidistant from the design center.

Consider the design matrix for a general equiradial design, say

$$D = \begin{bmatrix} x_{11} & x_{21} & \cdots & x_{k1} \\ x_{12} & x_{22} & \cdots & x_{k2} \\ \cdots & \cdots & \cdots & \cdots \\ x_{1N} & x_{2N} & \cdots & x_{kN} \end{bmatrix}.$$

Since all points are equidistant from the design center

$$\sum_{i=1}^{k} x_{iu}^2 = \rho^2 ,$$

where ρ is the distance of each point from the center, i.e., the radius of the polygon.

Now consider the quantity

$$N^{-1} \sum_{i=1}^{k} \sum_{u=1}^{N} x_{iu}^2 = N^{-1} \sum_{u=1}^{N} \left[\sum_{i=1}^{k} x_{iu}^2 \right] = N^{-1} \sum_{u=1}^{N} \rho^2 = \rho^2 \qquad (2.34)$$

The first term in equation (2.34) can also be written as $\sum_{i=1}^{k} \left[N^{-1} \sum_{u=1}^{N} x_{iu}^2 \right]$. Noting that the term inside the brackets is the second pure moment [ii], which by the usual scaling convention is equal to one, we have

$$\rho^2 = \sum_{i=1}^{k} \left[N^{-1} \sum_{u=1}^{N} x_{iu}^2 \right] = \sum_{i=1}^{k} [ii] = \sum_{i=1}^{k} (1) = k \tag{2.35}$$

Thus, under the usual scaling convention, ρ^2 is equal to k.

Now consider the quantity

$$\rho^4 = N^{-1} \sum_{u=1}^{N} \left[\sum_{i=1}^{k} x_{iu}^2 \right]^2 = N^{-1} \sum_{u=1}^{N} \left[\sum_{i=1}^{k} x_{iu}^4 + \sum_{\substack{i \\ (i \neq j)}} \sum_{j} x_{iu}^2 x_{ju}^2 \right] \tag{2.36}$$

$$= \sum_{i=1}^{k} \left[N^{-1} \sum_{u=1}^{N} x_{iu}^4 \right] + \sum_{\substack{i \\ (i \neq j)}} \sum_{j} \left[N^{-1} \sum_{u=1}^{N} x_{iu}^2 x_{ju}^2 \right]$$

We can see that, in the last line of equation (2.36), the first quantity in brackets is simply the fourth pure design moment [iiii] and the second quantity in brackets is the fourth even mixed moment [iijj]. Substituting this into equation (2.36) and completing the summations yields

$$k[iiii] + k(k-1)[iijj] = \rho^4 .$$

Since the designs must be rotatable, we can substitute λ_4 for [iijj] and $3\lambda_4$ for [iiii]. Also, by applying the usual scaling convention, we can substitute k^2 for ρ^4. These substitutions yield

$$3k\lambda_4 + k(k-1)\lambda_4 = k^2 ,$$

or

$$\lambda_4 = \frac{k}{k+2} . \tag{2.37}$$

This value of λ_4 makes (X'X) singular. This situation can be remedied in either of two ways:

1) Combine two or more equiradial sets of different radii about the same center, or

2) Augment the equiradial design with one or more center points.

We shall see shortly that method 2) is just a special case of method 1).

Box and Hunter (3) show that, for a combination of s equiradial rotatable sets

$$\lambda_4 = \frac{Nk \sum_{w=1}^{s} n_w \rho_w^4}{(k+2)\left(\sum_{w=1}^{s} n_w \rho_w^2\right)^2}, \tag{2.38}$$

where n_w is the number of points in the w^{th} set, ρ_w is the radius of the w^{th} set, and $N = \sum_w n_w$. Now the case of adding center points to an equiradial set is merely the case of $s = 2$, $\rho_2 = 0$. Substituting these values into equation (2.38) provides an expression for λ_4 when there are n_1 points in the equiradial set and n_2 points at the center,

$$\lambda_4 = \frac{k(n_1 + n_2)}{(k+2)\ n_1}. \tag{2.39}$$

For k=2, $\lambda_4 = (n_1+n_2)/2n_1$. Clearly in this case setting the number of center points equal to the number of radial points will make an orthogonal design. The values of n_2 that make uniform precision (or near uniform precision) and near minimum bias designs for k=2 are given in Table 2. Note that the n_2 values for near minimum bias are based upon a second pure moment of $[ii] = (.515)^2$, while those for uniform precision are based upon the usual scaling convention.

Table 2. Values of n_2 for Uniform Precision and Minimum Bias Equiradial Designs, k=2

n_1	5	6	7	8	9	10
n_2 (up)	3	3	4	4	5	6
n_2 (mb)	1	2	2	2	2	3

Now consider the concentric combination of two equiradial sets with $\rho_2 \neq 0$. Equation (2.38) becomes

$$\lambda_4 = \frac{N(n_1\ \rho_1^4 + n_2\ \rho_2^4)}{2(n_1\ \rho_1^2 + n_2\ \rho_2^2)^2} \tag{2.40}$$

Let

$$P = \frac{\rho_2}{\rho_1}$$

Then

$$\rho_2 = P\rho_1 \tag{2.41}$$

Substituting equation (2.41) into equation (2.40) yields

$$\lambda_4 = \frac{N(n_1\ \rho_1^4 + n_2 P^4\ \rho_1^4)}{2(n_1^2\ \rho_1^4 + n_2^2 P^2\ \rho_1^4 + 2n_1 n_2\ \rho_1^4)}$$

Simplifying this equation and collecting terms we have

$$\left[\lambda_4 n_2^2 - \frac{(n_1+n_2)}{2}\ n_2\right] P^4 + 2n_1 n_2 \lambda_4 P^2 + \left[\lambda_4 n_1^2 - \frac{(n_1+n_2)}{2}\ n_1\right] = 0 \tag{2.42}$$

For any combination of n_1 and n_2, we can substitute the desired values of λ_4 into this equation and solve for the appropriate value of P. It should be noted that, for any particular values of n_1 and λ_4, the value of n_2 which can be combined concentrically has a lower bound. This lower bound is equal to the number of center points which produced the same value of λ_4 when added to an equiradial set of n_1 points. Any value of n_2 less than the lower bound would require an imaginary value for P, hence the design could not be constructed. For the case of orthogonal combinations where $\lambda_4=1$, this means that we can never have $n_2 < n_1$, i.e., an orthogonal combination design with a radial octagon ($n_1=8$) can never be constructed with an interior set of less than eight points. In the uniform precision case ($\lambda_4 = .7844$) for example, combination designs with radial decagon ($n_1=10$) can never be constructed with an interior set of less than six points. For the minimum bias case λ_4 is sufficiently small that there is not a lower bound on the size of the interior equiradial set.

Table 3 gives the values of P which make various concentric combinations result in orthogonal, uniform precision, and minimum bias designs. Note that again the P values for minimum bias designs are based on a second pure moment of $[ii] = (.515)^2$, while those for orthogonal and uniform precision designs are based on the usual scaling convention of $[ii] = 1$.

2.4.2 Central Composite Designs

We shall compare various equiradial designs against the class of central composite designs. Box and Wilson (4) proposed this class of designs which consists of a 2^k factorial (first order) design of $F = 2^k$

Table 3. Values of $P = \rho_2/\rho_1$ for Orthogonal, Uniform Precision, and Minimum Bias Equiradial Designs, k=2

n_1	n_2	$R_{(orth)}$	$R_{(unif\ prec)}$	$R_{(min\ bias)}$
5	5	.000	.374	.581
	6	.204	.413	.597
	7	.267	.438	.607
	8	.304	.455	.614
	9	.330	.467	.618
	10	.348	.475	.620
6	5	----	.321	.560
	6	.000	.374	.581
	7	.189	.408	.595
	8	.250	.431	.604
	9	.287	.447	.611
	10	.314	.459	.615
7	5	----	.256	.537
	6	----	.330	.563
	7	.000	.374	.581
	8	.176	.404	.593
	9	.235	.425	.602
	10	.273	.441	.608
8	5	----	.170	.513
	6	----	.279	.545
	7	----	.337	.566
	8	.000	.374	.581
	9	.167	.401	.592
	10	.223	.420	.560
9	5	----	----	.488
	6	----	.217	.525
	7	----	.295	.550
	8	----	.342	.568
	9	.000	.374	.581
	10	.158	.398	.591
10	5	----	----	.462
	6	----	.129	.505
	7	----	.246	.534
	8	----	.306	.554
	9	----	.346	.569
	10	.000	.374	.581

factorial points augmented by n_2 center points and 2k axial points to allow fitting of a second order model. The design matrix for a central composite design in two variables would be

$$D = \begin{bmatrix} -1 & & -1 \\ 1 & & -1 \\ -1 & & 1 \\ 1 & & 1 \\ 0 & & 0 \\ & \cdots & \\ 0 & & 0 \\ -\alpha & & 0 \\ \alpha & & 0 \\ 0 & & -\alpha \\ 0 & & \alpha \end{bmatrix} .$$

Since the factorial portion will always contain $F = 2^k$ points and the axial portion will always contain k pairs of points such that one factor at a time has the values $+\alpha$ and $-\alpha$ while all other factors are zero, we can see that in general all odd moments will be zero, and

$$N[iiii] = \sum_{u=1}^{N} x_{iu}^4 = F + 2\alpha^4 \tag{2.43}$$

$$N[iijj] = \sum_{u=1}^{N} x_{iu}^2 x_{ju}^2 = F . \tag{2.44}$$

To make these designs rotatable we must require that

$$[iiii] = 3[iijj] . \tag{2.45}$$

Substituting equations (2.43) and (2.44) into equation (2.45) and solving for α gives

$$\alpha = (F)^{\frac{1}{4}} , \tag{2.46}$$

the value of α which will insure rotatability.

It can also be shown that, if we multiply each point by a factor of $[N/(F + 2\alpha^2)]^{\frac{1}{2}}$ to scale the design to the usual convention of $[ii] = 1$, then

$$\lambda_4 = N/(F + 4F^{\frac{1}{2}} + 4) \ . \tag{2.47}$$

Desired values of λ_4 can be achieved by varying the number of center points n_2 and thus varying N.

Values of n_2 and α for the central composite designs which we will use in this study are given in Table 4 below.

Table 4. Values of n_2 and α for Orthogonal, Uniform Precision, and Minimum Bias Central Composite Designs, k=2

	n_2	α
Orthogonal	8	1.414
Uniform Precision	5	1.414
Minimum Bias	2	0.799

CHAPTER III

EXPERIMENTAL DEVELOPMENT

3.1 Background

In Evans' (6) masters thesis and a subsequent paper by Montgomery and Evans (7) the basic work of Brooks (5) was taken as a starting point for the study of second order response surface designs as applied to digital simulation. To the four surfaces of Brooks, Evans added two more. One was a modification of Rosenbrock's curved valley, and the other was a very irregular surface derived from an inverse polynomial function. Evans fitted each of the designs in his study at several points on each surface and at various values of the experimental error variance. He then compared the performance characteristics of the designs.

An investigation similar to that of Evans will be conducted to study further the class of equiradial designs.

3.2 The Response Surfaces

The six response surfaces used by Evans, which will also be used in this study, are shown in Figure 1. Surfaces 1 through 4 in Figure 1 were employed by Brooks, and each has a single maximum $y=1$ at $x_1=1$, $x_2=1$. Figure 1 shows the contour lines $y=0.25$, 0.50, and 0.75 for these four surfaces. Surface 5 is Evans' modification of Rosenbrock's curved valley. This surface has a maximum of $y= -1$ at $x_1=1$, $x_2=1$. Figure 1(e) shows the contour lines $y= -9$, -5, -2, and -1.5 for Surface 5. Surface 6 is Evans' inverse polynomial surface. This surface has a maximum of $y=4.173749909$ at $x_1=2.4475$, $x_2=3.8875$. Figure 1(f) shows the contour lines $y=4.15$, 4.05, 3.85, and 3.75 for Surface 6. Mathematically, the surfaces are defined as follows:

<u>Surface 1</u>

$$y = (0.5 + 0.5\,x_1)^4\, x_2^4 \exp[2 - (0.5 + 0.5\,x_1)^4 - x_2^4] + \epsilon\ .$$

This is a response surface in which the two factors are independent of each other.

<u>Surface 2</u>

$$y = (0.3 + 0.4\,x_1 + 0.3\,x_2)^4\,(0.8 - 0.6\,x_1 + 0.8\,x_2)^4$$

$$\exp[2 - (0.3 + 0.4\,x_1 + 0.3\,x_2)^4 - (0.8 - 0.6\,x_1 + 0.8\,x_2)^4] + \epsilon\ .$$

This is equivalent to Surface 1 rotated approximately 37 degrees, representing a dependence between x_1 and x_2.

<u>Surface 3</u>

$$y = x_1^2 \exp[1 - x_1^2 - 20.25\,(x_1 - x_2)^2] + \epsilon\ .$$

This surface is a sharp narrow ridge with large flat areas of low response.

<u>Surface 4</u>

$$y = (0.3\,x_1^2 + 0.7\,x_2^2)^3 \exp[1 - 0.6(x_1 x_2)^2 - (0.3\,x_1^2 + 0.7\,x_2^2)^3] + \epsilon\ .$$

This surface is a relatively flat curvilinear ridge.

<u>Surface 5</u>

$$y = -\,[1 + 100\,(x_2 - x_2^2)^2 + (1 - x_1)^2] + \epsilon\ .$$

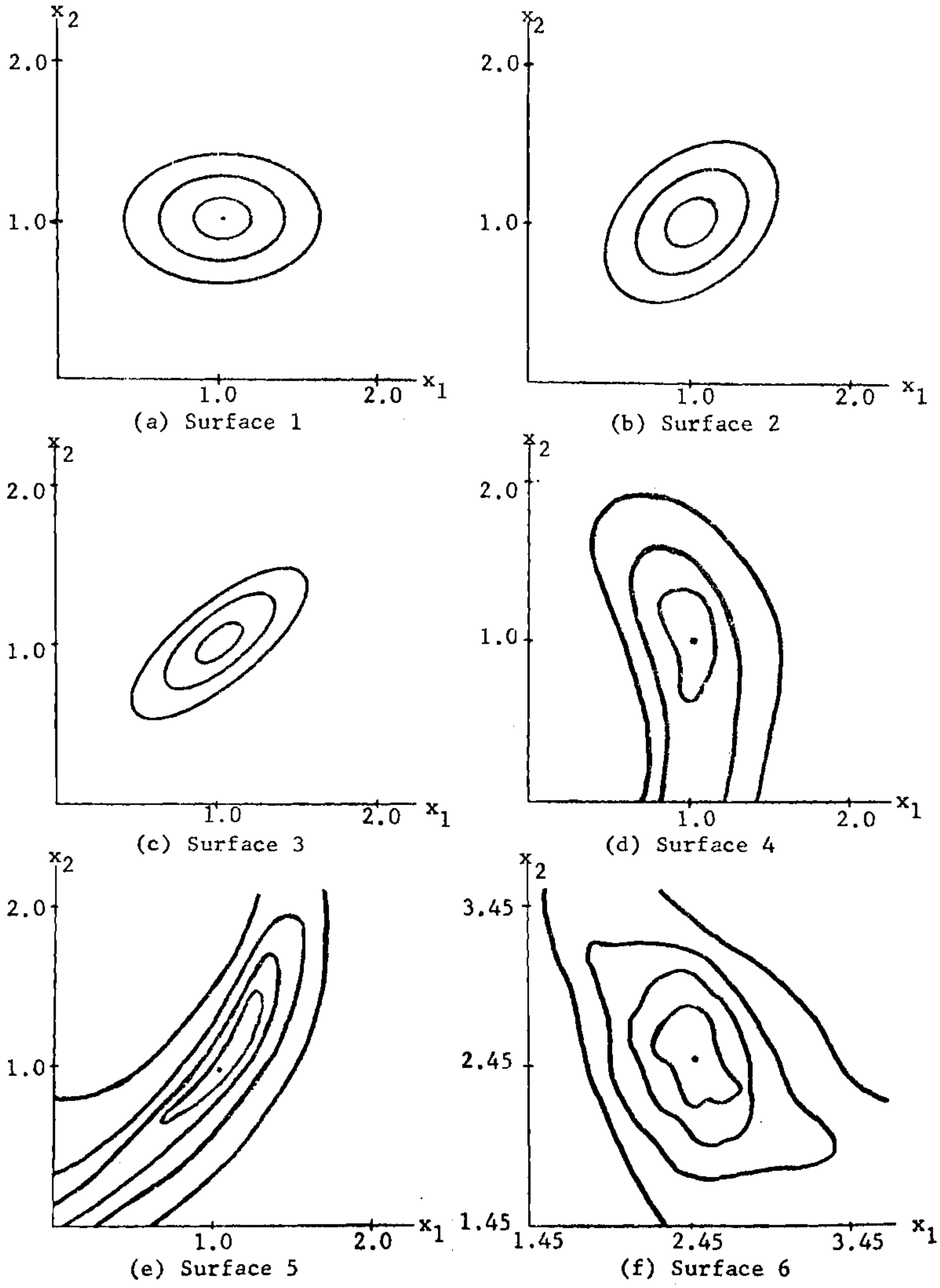

Figure 1. Response Surfaces

This surface is a steep curved ridge.

Surface 6

$$y = [(x_1x_2)/(.9 + .066\ x_1 - .001\ x_2 - .01\ x_1^2 + .03\ x_2^2$$

$$+ .005\ x_1x_2 + .01\ x_1^2x_2 - .017\ x_1x_2^2 + .013\ x_1^2x_2^2)] + \epsilon\ .$$

This is a low, bumpy, irregular surface.

3.3 Comparison Between Designs

In order to make valid comparisons between experimental designs and their performance on a group of surfaces, it is necessary that the "spread" of the designs be equal.

The usual measure of spread is the second pure design moment $[ii] = \lambda_2$. The problem is to insure that designs to be compared are scaled to the same convention. As mentioned previously, the usual scaling convention is $\lambda_2 = 1$. In this study, however, we wish to compare a group which includes minimum bias designs. As noted earlier, the minimum bias design for two factors should have $\lambda_2 = (.515)^2$. Therefore, throughout this investigation we will use $\lambda_2 = (.515)^2$ as our scaling convention.

In the case of central composite designs this can be accomplished by multiplying each design point of a central composite design scaled to the usual convention by a factor of (.515). In the case of equiradial designs it is simpler to scale the design by appropriate selection of the design radius ρ_1.

The design matrix for a rotatable equiradial design in two variables can be generated by the relationship

$$\begin{aligned} x_{1u} &= \rho_1 \cos[\theta + (2\pi u)/n_1] \\ x_{2u} &= \rho_1 \sin[\theta + (2\pi u)/n_1] \end{aligned} \qquad (u=0,1,\ldots,n_1-1) \tag{3.1}$$

where θ is the angle that the first design point makes with the x_1 axis, and n_1 is the number of points in the equiradial set. Center points must of course be added to complete the design generated by equation (3.1).

To generate a combination design with n_1 radial points, n_2 inner points, and $\rho_2/\rho_1 = P$ we use the relationship

$$\begin{aligned} x_{1u} &= \rho_1 \cos[\theta + (2\pi u)/n_1] \\ x_{2u} &= \rho_1 \sin[\theta + (2\pi u)/n_1] \end{aligned} \qquad (u=0,1,\ldots,n_1-1)$$
$$\begin{aligned} x_{1(n_1+v)} &= P\rho_1 \cos[\theta + (2\pi v)/n_2] \\ x_{2(n_1+v)} &= P\rho_1 \sin[\theta + (2\pi v)/n_2] \end{aligned} \qquad (v=0,1,\ldots,n_2-1) \tag{3.2}$$

It can be shown that the second pure design moment for such a design is

$$[ii] = \lambda_2 = \frac{\rho_1^2(n_1 + n_2P^2)}{2(n_1 + n_2)} \; . \tag{3.3}$$

Solving equation (3.3) for ρ_1 gives

$$\rho_1 = \left[\frac{2N\lambda_2}{n_1 + n_2P^2}\right]^{\frac{1}{2}} \; . \tag{3.4}$$

For the case of an equiradial set augmented by n_2 center points, P is zero and equation (3.4) reduces to

$$\rho_1 = \left[\frac{2N\lambda_2}{n_1}\right]^{\frac{1}{2}} . \tag{3.5}$$

We can use equations (3.4) and (3.5) to give us the design radii which will make $\lambda_2 = (.515)^2$ in each of our equiradial designs. Appendix A contains representative examples of the design matrices generated in this manner and their associated moment matrices.

A second point which concerns us in the comparison of designs is the coding of the design on the region of interest, i.e., the area of the surface to be investigated. In order that each design investigated cover the same area of the true response surface, a coding factor of CF = $\rho_1/.29$ for equiradial designs and CF = $\alpha/.29$ for central composite designs is used. This will insure that each design covers an area with a radius of .29 surface units. The coding of the designs to the surfaces is given by the relationship

$$x_i\,(\text{surface}) = \frac{x_i\,(\text{design})}{\text{CF}} \tag{3.6}$$

Evans (6) conducted a series of steepest ascent experiments on each of the surfaces in Figure 1. He calculated an average linear deviation of the optimum found by steepest ascent from the true optimum. This linear deviation was 0.11 surface units for surfaces 3 and 5, and 0.18 for the remaining surfaces.

In this investigation thirty design centers are selected for each surface. On each surface these design centers are equally spaced along a circle about the true optimum with the radius of the circle equal to the average linear deviation determined by Evans. The coding scheme established for this investigation insures that the true optimum will always lie within designs centered as described above.

3.4 The Computer Program

This investigation required the use of seven main programs and one common subroutine. The main programs differ only in the portion of the program which generates the designs. The main programs correspond to the following groupings of designs:

1) Equiradial sets augmented by center points
2) Orthogonal equiradial combinations
3) Uniform precision equiradial combinations
4) Minimum bias equiradial combinations
5) Orthogonal central composite
6) Uniform precision central composite
7) Minimum bias central composite

The subroutine contains the response functions for the six surfaces.

Appendix B contains a listing of one main program and the surface subroutine. A generalized flow chart of the computer program appears in Figure 2.

The random error component used in the program is assumed to be normally distributed with zero mean and standard deviation σ_ϵ. The error standard deviation takes on values from zero, representing no error in the experimental observations through 0.03, 0.06, 0.09, 0.12, and 0.15.

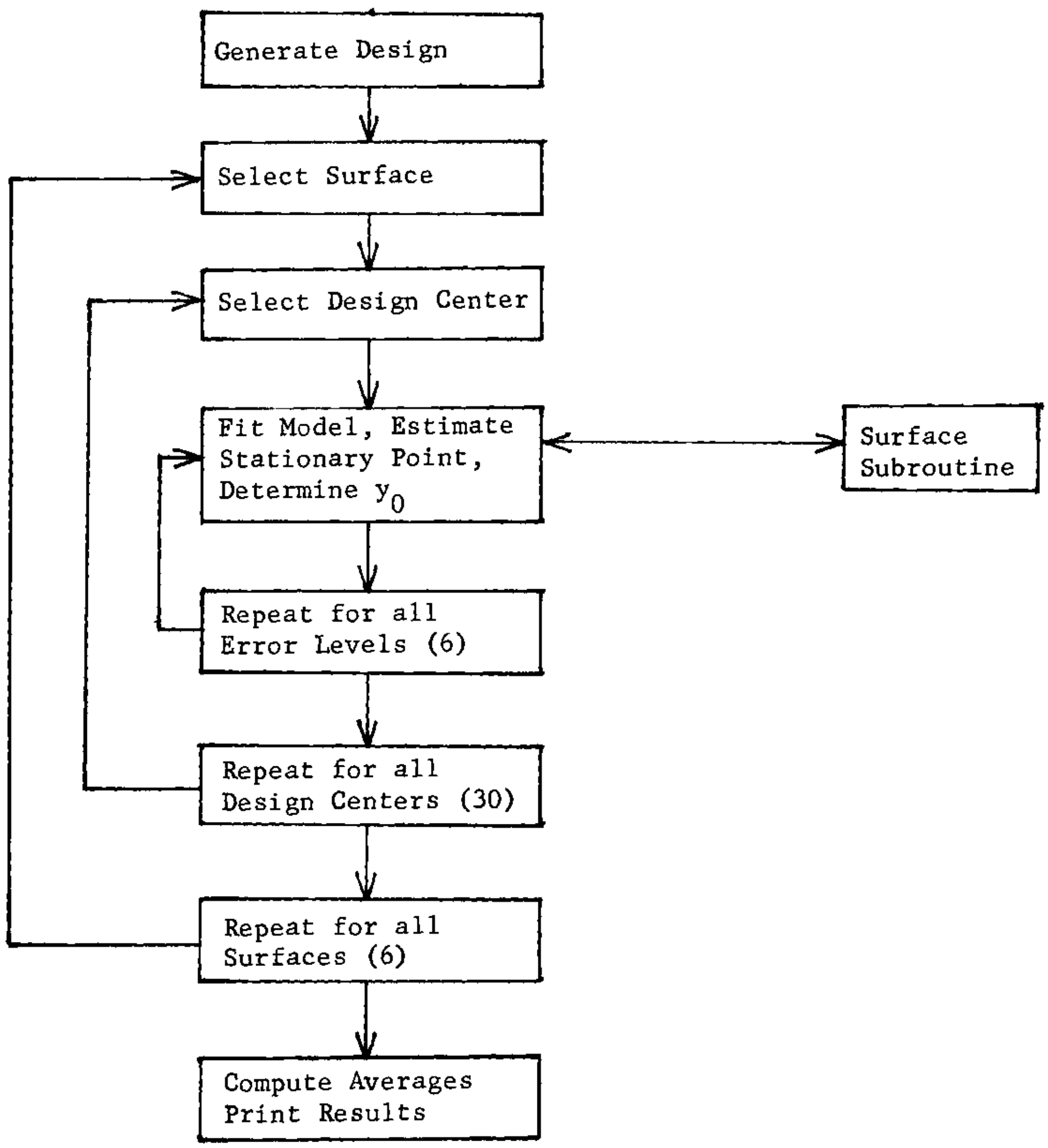

Figure 2. Generalized Flow Chart of Computer Program

CHAPTER IV

EXPERIMENTAL RESULTS

4.1 Measures of Effectiveness

This study applies two measures of effectiveness to the designs investigated. These measures are stationary point deviation (D) and response achievement (R). The first measures the average distance of the estimated optimal factor combination from the true optimal factor combination. Defining (x_{10}, x_{20}) as the estimated optimal combination and (x_{1*}, x_{2*}) as the true optimal combination, the stationary point deviation measure is then

$$D = [(x_{10} - x_{1*})^2 + (x_{20} - x_{2*})^2]^{\frac{1}{2}} . \tag{4.1}$$

The second measure of effectiveness compares the estimated optimal response against the true optimal response. Defining y_0 as the estimated optimum and y_* as the true optimum, the response achievement is then

$$R = \frac{y_0}{y_*} . \tag{4.2}$$

This is simply the percentage of optimal response which is achieved by the estimated response y_0.

Due to the large number of designs investigated and the fact that the nature of the surface is usually unknown in a response surface investigation, experimental results will be evaluated by design groups only.

A total of 133 designs was investigated. Each design was fitted on each of the six surfaces at 30 different design centers for each surface and six different error levels for each design center. This amounts to 1080 experiments for each design, or a total of 143,640 experiments. The 30 design centers for each surface were preselected to be equally spaced on a circle about the true optimum. The radius of the circle in each case was equal to the average linear deviation of the steepest ascent method as determined by Evans (6). The performance results for each design are averaged over all design centers and tabulated by surface and error level. The individual design performance results may be found in Appendix C.

It is impractical to analyze and compare the individual performance characteristics of 133 designs. Instead, designs will be collected in certain logical groupings, these groups analyzed, and then the "best performers" of each group will be compared. The groupings will be as follows:

1) Equiradial sets augmented by center points
2) All uniform precision designs
3) All orthogonal designs
4) All minimum bias designs
5) "Best performers" from each of the above.

4.2 Experimental Results by Design Groups

In this section the performance of designs within the various groupings will be analyzed. The results of this analysis should provide insight for the experimenter in the selection of an experimental design for investigation of an unknown response surface.

4.2.1 Equiradial Sets Augmented by Center Points

This group of designs includes all designs with n_1 ranging from 5 through 10 and n_2 ranging from 1 to n_1.

Table 5 shows the average distance (D) and response (R) achievements for equiradial pentagon designs with from 1 to 5 center points. The best results among these designs is achieved when $n_0=3$ which corresponds to a uniform precision design. The performance of pentagon designs improves as center points are added up to the uniform precision case and declines thereafter.

Table 6 shows the average D and R achievements for equiradial hexagon designs with from 1 to 6 center points. The best results among these is also achieved when $n_0=3$, the uniform precision configuration. As with the pentagon designs, the hexagon design performance improves with the addition of center points up to uniform precision and then declines.

Table 7 shows the performance achievements for equiradial heptagon designs with from 1 to 7 center points. The best results among the heptagons is achieved when $n_0=1$. Performance of the other designs in this group is irregular and there is no apparent trend associated with the addition of center points.

Table 8 shows performance achievements for equiradial octagon designs with 1 to 8 center points. The best performance in this group is achieved with $n_0=1$. The D achievement is irregular throughout; however, the R achievement declines from $n_0=1$ to $n_0=3$ and improves thereafter.

Table 9 shows performance achievements for equiradial nonegon designs with from 1 to 9 center points. For these designs the best R

Table 5. Distance (D) and Response (R) Achievement for Pentagon Designs

n_1	n_0	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
5	1	D	.20886	.22227	.37046	1.16629	.67986	.35625	.50067	Min Bias
		R	.89848	.90559	.90945	.91161	.91117	.90289	.90653	
	2	D	.20886	.25029	.21209	.27349	.19440	.20438	.22392	
		R	.89848	.90536	.91214	.89831	.90339	.90701	.90412	
	3	D	.20886	.17828	.19105	.19817	.18536	.21288	.19577	Unif Prec
		R	.89848	.90798	.90230	.90146	.91495	.90575	.90500	
	4	D	.20886	.33023	.17538	.20812	.45318	.21397	.26496	
		R	.89848	.90470	.91511	.89801	.89045	.89580	.90043	
	5	D	.20886	.17868	.20773	.19896	.53203	.71468	.34016	Orth
		R	.89848	.90532	.90587	.90928	.87151	.87318	.89394	

Table 6. Distance (D) and Response (R) Achievement for Hexagon Designs

n_1	n_0	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
6	1	D	.35644	.23694	.29346	2.04580	.27965	.25582	.57802	
		R	.91273	.92604	.92502	.92131	.91685	.91226	.91903	
	2	D	.35641	.23676	.32523	.49703	.26240	.26807	.32432	Min Bias
		R	.91273	.92592	.92523	.92181	.91760	.91321	.91942	
	3	D	.35641	.24143	.46032	.25932	.31836	.29018	.32100	Unif Prec
		R	.91273	.92499	.92566	.92346	.92026	.91669	.92063	
	4	D	.35642	.95807	.94970	.50812	.37444	.37640	.58719	
		R	.91273	.88726	.80951	.88992	.89806	.89171	.88153	
	5	D	.35643	.91918	.42379	.37815	2.10942	.36475	.75862	
		R	.91273	.85424	.89816	.89631	.89080	.86883	.88684	
	6	D	.35643	.53235	.32173	.34171	.39284	.79841	.45725	Orth
		R	.91273	.88527	.89725	.89442	.87167	.81816	.87992	

Table 7. Distance (D) and Response (R) Achievement for Heptagon Designs

n_1	n_0	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
7	1	D	.23230	.45381	.26752	2.30610	.28417	.48981	.67228	
		R	.91268	.92331	.92178	.91768	.91261	.90702	.91585	
	2	D	.23230	.45359	1.99721	2.48976	1.63027	.81217	1.26922	Min Bias
		R	.91268	.91430	.79214	.73536	.79179	.80286	.82485	
	3	D	.23230	.36103	.35481	.37217	.43864	9.31214	1.84518	
		R	.91268	.87610	.87739	.86819	.82209	.75815	.85243	
	4	D	.23230	.39514	.34608	.35044	.73220	1.01151	.51128	Unif Prec
		R	.91268	.87851	.86759	.84384	.78699	.70611	.83262	
	5	D	.23230	.31658	.34969	.63438	.64425	308.65037	51.80459	
		R	.91268	.87993	.86780	.82276	.73962	.68238	.81753	
	6	D	.23230	.52578	.32613	.35713	.48177	8.01068	1.65563	
		R	.91268	.87788	.87952	.87176	.83467	.77874	.85921	
	7	D	.23230	.35285	.33629	.35867	.44116	.92768	.44149	Orth
		R	.91268	.87792	.87597	.86942	.82576	.76523	.85450	

Table 8. Distance (D) and Response (R) Achievement for Octagon Designs

n_1	n_0	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
8	1	D	.22013	.28448	.28739	.32691	.33798	.33776	.29911	
		R	.91756	.91155	.89914	.88250	.86928	.85208	.88869	
	2	D	.22013	.37447	.47941	.84407	1.62640	1.44613	.83177	Min Bias
		R	.91756	.88308	.85836	.73911	.58475	.60835	.76520	
	3	D	.22013	.38947	.48892	1.41168	1.76531	2.02253	1.04967	
		R	.91756	.88319	.85938	.73695	.55534	.60433	.75946	
	4	D	.22013	.37223	.47859	1.19587	1.93390	1.35333	.92568	Unif Prec
		R	.91756	.88303	.85786	.74326	.59756	.60977	.76817	
	5	D	.22013	.35845	.39782	.72275	.57854	1.99065	.71222	
		R	.91756	.88803	.87711	.85221	.80821	.73920	.84705	
	6	D	.22013	.33381	.38385	.82958	.58630	.86900	.53711	
		R	.91756	.88772	.87666	.85200	.80653	.73516	.84594	
	7	D	.22013	.32423	.36416	.48356	1.65411	.61983	.61100	
		R	.91756	.89154	.87840	.85519	.81951	.76264	.85414	
	8	D	.22013	.40307	.33326	.41561	1.02726	.77859	.52965	Orth
		R	.91756	.89353	.87777	.85816	.82586	.77336	.85771	

Table 9. Distance (D) and Response (R) Achievement for Nonegon Designs

n_1	n_0	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
9	1	D	.21998	.96949	1.00514	3.30275	11.61080	1.45137	3.09326	
		R	.91862	.78742	.66438	.56207	.59403	.59582	.68706	
	2	D	.21997	1.13358	.55306	1.07063	2.57669	1.21563	1.12826	Min Bias
		R	.91862	.81178	.79560	.59917	.55717	.58265	.71083	
	3	D	.21997	.73891	.52418	1.09366	2.39160	1.77100	1.12322	
		R	.91862	.83891	.81444	.65283	.58324	.56708	.72919	
	4	D	.21997	.36483	.56936	.50017	5.44648	1.32133	1.40369	
		R	.91862	.88942	.84901	.81639	.75657	.64456	.81243	
	5	D	.21997	.36337	.51063	.68612	1.99586	2.60746	1.06390	Unif Prec
		R	.91862	.88984	.84829	.82220	.75015	.65938	.81475	
	6	D	.21997	.35221	.54613	.51523	.57182	.64661	.47533	
		R	.91862	.89613	.85938	.82678	.79671	.73618	.83897	
	7	D	.21997	.51438	.76356	.63303	.47165	.97193	.59576	
		R	.91862	.89665	.87200	.83523	.80332	.75741	.84720	
	8	D	.21997	.37261	.78487	.46895	.57838	.79262	.53623	
		R	.91862	.89266	.85528	.82584	.78769	.70633	.83107	
	9	D	.21997	20.45302	.77091	.44755	.54126	1.06284	3.91592	Orth
		R	.91862	.89703	.87286	.83675	.80358	.75828	.84785	

achievement is reached when n_0=9, the orthogonal case. The corresponding D achievement, however, is the worst of all the nonegon designs. The best D is achieved when n_0=6, and the corresponding R is only slightly lower than the best. Again there is no apparent trend in D achievement; however, R achievement improves throughout except when n_0=8.

Table 10 shows performance achievements for equiradial decagon designs with from 1 to 10 center points. The best R performance for the decagon designs is achieved by the orthogonal design (n_0=10). However, the best D performance is achieved when n_0=9, and the R achievement of this design is only slightly less than that of the orthogonal decagon. Among equiradial decagon designs there is no apparent trend associated with the addition of center points.

Considering the entire group of equiradial designs augmented by center points, it can be observed that, when the error level is zero, the addition of more center points to a design has little or no effect on design performance. While this is not true in the presence of error, there is no clear trend for all of these designs as the number of center points is increased. This is shown graphically in Figure 3. The pentagon and hexagon designs perform consistently better than other designs with the same number of center points. The best D achievement was by the uniform precision pentagon, and the best R achievement was by the uniform precision hexagon.

4.2.2 Uniform Precision Designs

Table 11 shows the distance and response achievements for all uniform precision designs. This includes the six uniform precision designs from the previous section which were achieved by an appropriate number of

Table 10. Distance (D) and Response (R) Achievement for Decagon Designs

n_1	n_0	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
10	1	D	.21990	1.20983	.40152	1.80417	1.12934	1.10097	.97762	
		R	.91861	.80911	.84063	.66762	.66146	.65664	.77251	
	2	D	.21991	15.13965	.54562	4.11109	1.57115	1.25723	3.80744	
		R	.91861	.88774	.83323	.64500	.66713	.64437	.76601	
	3	D	.21990	.35664	.87498	.41219	.76165	.47474	.51669	Min Bias
		R	.91861	.90598	.88070	.86891	.83205	.76978	.86267	
	4	D	.21990	.52620	1.39106	.71905	.40357	.77346	.67221	
		R	.91861	.86147	.88188	.85703	.81644	.70113	.83943	
	5	D	.21990	.39817	1.63688	.40017	.39690	.55932	.60189	
		R	.91861	.89741	.88255	.86666	.82617	.74504	.85607	
	6	D	.21990	.38599	1.26147	.40078	.39950	.52937	.53283	Unif Prec
		R	.91861	.90022	.88308	.86659	.82750	.75223	.85804	
	7	D	.21990	4.01245	.72088	.39999	.43615	31.50362	6.21550	
		R	.91861	.83606	.88352	.85284	.79459	.67685	.82708	
	8	D	.21990	.50161	1.68213	.74657	.40177	.73274	.71412	
		R	.91861	.86786	.88214	.85766	.81793	.70678	.84183	
	9	D	.21990	.33295	.65001	.44214	.43186	.44084	.41962	
		R	.91861	.90962	.88390	.87280	.83813	.78689	.86833	
	10	D	.21990	.30356	.60134	.61624	.51594	.42173	.44645	Orth
		R	.91861	.91314	.86859	.87262	.84596	.80943	.87139	

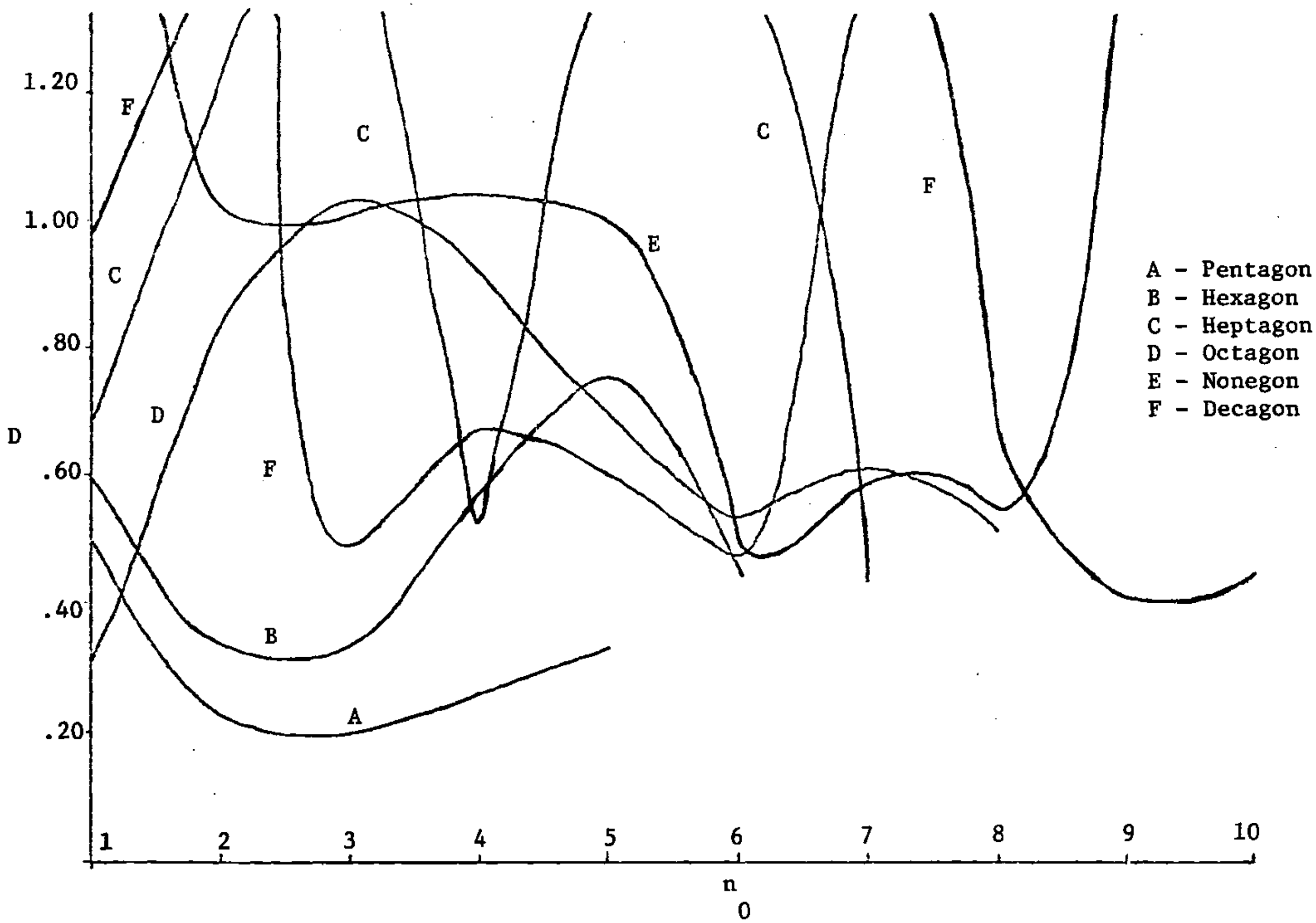

Figure 3. Distance (D) Achievement for Equiradial Designs with Various Center Points n_0

Table 11. Distance (D) and Response (R) Achievement for Uniform Precision Designs

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
5	3	.000	D	.20886	.17828	.19105	.19817	.18536	.21288	.19577	Center Points
			R	.89848	.90708	.90230	.90146	.91495	.90575	.90500	
	5	.374	D	.23162	.18474	.20796	.20838	.23741	1.14090	.36850	
			R	.88712	.89794	.89512	.90429	.90079	.85206	.88955	
	6	.413	D	.29792	.21266	.22579	.42690	.89346	.46019	.41949	
			R	.88186	.89206	.89549	.88084	.83311	.85187	.87254	
	7	.438	D	.28724	.21688	.32438	.45984	.77806	.33213	.39976	
			R	.87319	.88082	.88290	.86094	.79984	.84404	.85695	
	8	.455	D	.31281	.20886	.69960	.25850	.34600	.46489	.38178	
			R	.87479	.88179	.88643	.88386	.86696	.84604	.87331	
	9	.467	D	.41386	.21944	.32102	.29534	.36478	1.13810	.45876	
			R	.87073	.88081	.88149	.85989	.85784	.85132	.86701	
	10	.475	D	1.62323	.23930	.26526	.35324	.52733	.72058	.62149	
				.86426	.87701	.86537	.86143	.85800	.85120	.86288	
6	3	.000	D	.35641	.24143	.46032	.25932	.31836	.29018	.32100	Center Points
			R	.91273	.92499	.92566	.92346	.92026	.91669	.92063	
	5	.321	D	.27075	.58612	.37350	.72400	.38192	.75159	.51465	
			R	.91850	.87544	.89855	.89492	.88223	.84606	.88595	
	6	.374	D	.23133	.48852	.36184	1.00694	1.12334	2.13162	.89060	
			R	.91780	.86895	.89487	.88759	.85268	.79731	.86986	
	7	.408	D	.22192	.59168	4.61824	.47302	.49456	.52328	1.15378	
			R	.91482	.88658	.81396	.86855	.85769	.82980	.86190	
	8	.431	D	.22442	.32682	4.91450	1.55632	.64692	.66704	1.38934	
			R	.90739	.92083	.84122	.79449	.82329	.82698	.85237	

Table 11. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
6	9	.447	D	.24381	.30314	.61057	1.58918	2.30237	1.44793	1.08283	
			R	.88703	.91866	.91072	.80867	.72550	.74336	.83232	
	10	.459	D	.31634	.35671	.82893	1.27718	.77620	2.12712	.94708	
			R	.87159	.91024	.80227	.80979	.78022	.80962	.83062	
7	4	.000	D	.23230	.39514	.34608	.35044	.73220	1.01151	.51128	Center Points
			R	.91268	.87851	.86759	.84384	.78699	.70611	.83262	
	5	.256	D	.23699	.45341	1.28675	.40516	1.07796	.88524	.72425	
			R	.90831	.87120	.85846	.80763	.72979	.67905	.80907	
	6	.330	D	.28328	.50829	5.53907	.59719	.66068	5.01003	2.09976	
			R	.90076	.87666	.87929	.85121	.78807	.72624	.83704	
	7	.374	D	.39567	.64036	.87797	.56750	1.61557	1.27002	.89452	
			R	.89532	.87496	.87478	.85231	.79297	.73307	.83723	
	8	.404	D	.76416	.52214	.43304	.45928	.43673	.67102	.54773	
			R	.89594	.88022	.87409	.85760	.80400	.74757	.84324	
	9	.425	D	.86656	.35727	.40264	.35604	.73476	1.11869	.63933	
			R	.89039	.87368	.87186	.84914	.79865	.74375	.83791	
	10	.441	D	.65562	.39585	.45463	.37186	.76173	.48616	.52098	
			R	.88575	.85492	.86059	.82907	.77001	.72926	.82160	
8	4	.000	D	.22013	.37223	.47859	1.19587	1.93390	1.35333	.92568	Center Points
			R	.91756	.88303	.85786	.74326	.59756	.60977	.76817	
	5	.170	D	.21459	.42348	.34103	.43792	3.89313	.91511	1.03754	
			R	.91949	.88708	.87452	.84742	.79439	.72096	.84064	
	6	.279	D	.21673	.31692	.32211	.37016	.64675	1.28950	.52703	
			R	.92229	.89142	.87193	.84231	.78461	.70487	.83624	

Table 11. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
8	7	.337	D	.23657	.28236	.43698	.33179	.41857	.87331	.42993	
			R	.92387	.89572	.87407	.84807	.79887	.73007	.84511	
	8	.374	D	.29242	.29880	.32786	.32759	.41103	.79024	.40799	
			R	.92475	.89613	.87352	.84799	.79648	.72569	.84410	
	9	.401	D	.53802	.47050	.31668	.36555	1.30288	.97865	.66205	
			R	.92519	.88760	.86587	.82915	.76173	.68281	.82539	
	10	.420	D	.92071	.46200	.34623	.37914	.90471	1.63489	.77461	
			R	.92527	.89082	.86632	.83103	.76690	.69579	.82936	
9	5	.000	D	.21997	.36337	.51063	.68612	1.99586	2.60746	1.06390	Center Points
			R	.91862	.88984	.84829	.82220	.75015	.65938	.81475	
	6	.217	D	.21339	.28087	.60043	.48432	.57236	5.22649	1.22964	
			R	.92141	.90439	.86199	.81012	.76854	.68129	.82462	
	7	.295	D	.21961	.25791	.41394	1.02556	.75877	.70232	.56302	
			R	.92330	.90855	.86277	.81402	.77113	.69678	.82942	
	8	.342	D	.24083	.25255	.43754	.92009	1.34032	1.66638	.80962	
			R	.92440	.90485	.84381	.77988	.67949	.64422	.79611	
	9	.374	D	.29347	.24866	.31408	.98289	.64960	.87962	.56139	
			R	.92500	.90838	.85953	.80758	.74742	.64395	.81531	
	10	.398	D	.47961	.25992	.26334	.36882	1.03791	1.12222	.58864	
			R	.92529	.91247	.88635	.83299	.78257	.72045	.84335	
10	6	.000	D	.21990	.38599	1.26147	.40078	.39950	.52937	.53283	Center Points
			R	.91861	.90022	.88308	.86659	.82750	.75223	.85804	
	6	.129	D	.21620	.36801	.62473	.43424	.40632	.53670	.43103	
			R	.91966	.90252	.87988	.86484	.82571	.75091	.85726	

Table 11. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
10	7	.246	D	.21389	1.97701	.60013	.58084	1.24926	13.36485	2.99766	
			R	.92209	.85723	.87674	.84700	.77706	.66838	.82475	
	8	.306	D	.22239	.50408	.41929	.76818	.47612	.61363	.49895	
			R	.92357	.86199	.87524	.85634	.80300	.69572	.83598	
	9	.346	D	.24417	.28169	.34419	.44784	.56594	.83026	.45235	
			R	.92448	.91802	.90219	.85382	.83101	.78602	.86926	
	10	.374	D	.29353	.27528	.48957	.35064	.49061	.60934	.41816	
			R	.92501	.92067	.88414	.86579	.82690	.79767	.87003	
--	--	CCD	D	.22006	.25483	.31944	1.21097	.77591	.44144	.53711	CCD
			R	.91756	.91905	.91525	.84334	.79089	.88840	.87908	

center points, all uniform precision equiradial combination designs achieved by an appropriate value of ρ_2/ρ_1, and the uniform precision ccd.

The best performances in this group are achieved by the same designs which were best in the last group. That is, the uniform precision pentagon has the best distance achievement, and the uniform precision hexagon has the best response achievement. There are no clear trends associated with the number of points in the interior equiradial set. However, it can be observed that, for each combination of equiradial sets, the best performance is generally achieved when the larger set has the smaller radius. For example, it is seen that the pentagon with interior hexagon performs better then the hexagon with interior pentagon. This is shown graphically for pentagon combinations in Figure 4. It can also be seen that the pentagon and hexagon designs perform consistently better than larger designs when the same equiradial sets are used for the interior portion.

These observations are somewhat gratifying since they indicate that better performance and economy in the number of observations can be gained simultaneously. In this respect it should be noted that the uniform precision pentagon and hexagon both performed considerably better than the uniform precision central composite design.

4.2.3. Orthogonal Designs

This section analyzes the performance of all orthogonal designs as shown in Table 12 including the six obtained by augmenting equiradial sets with center points, 15 obtained by appropriate selection of ρ_2/ρ_1 for equiradial combinations, and the orthogonal ccd.

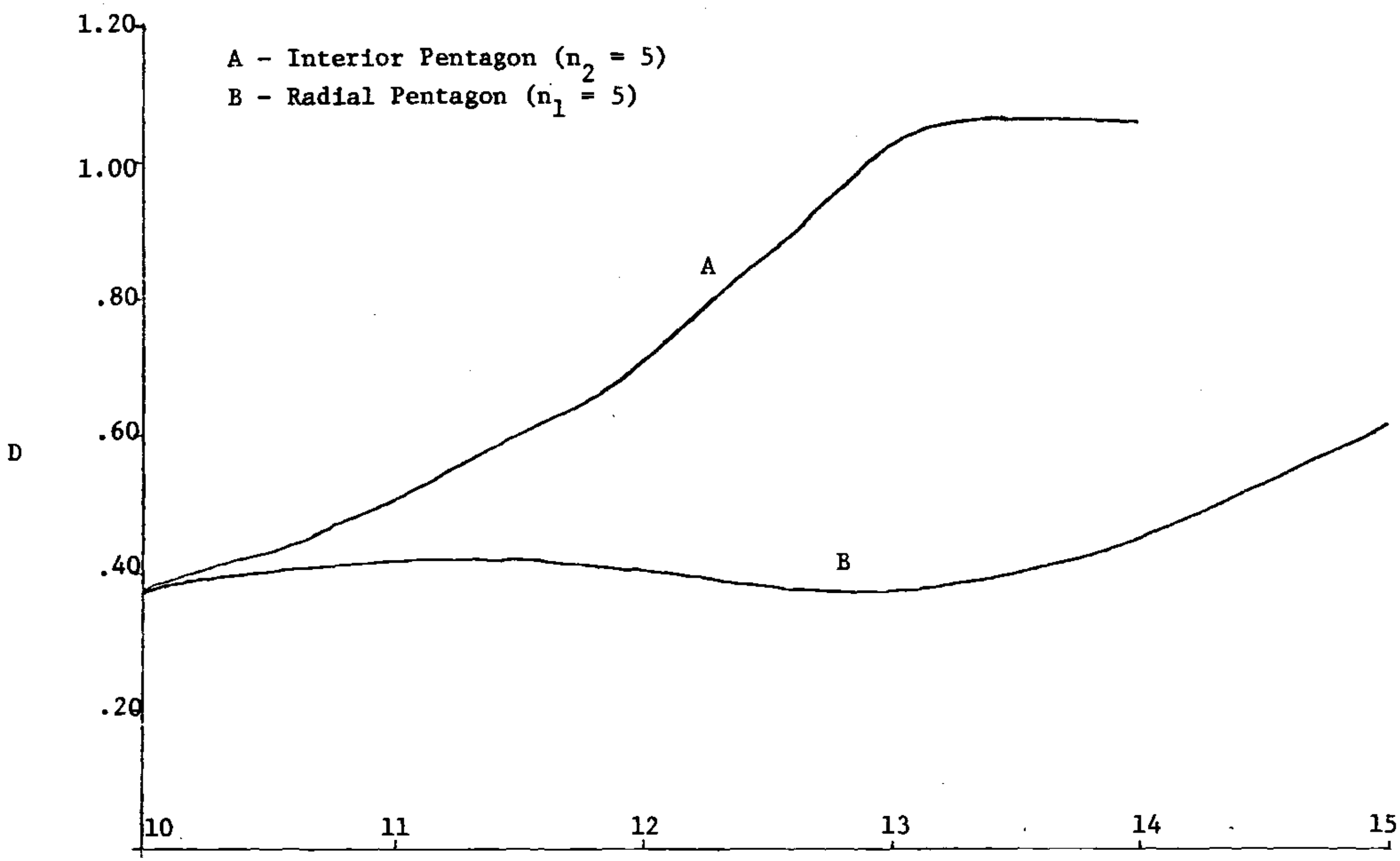

Figure 4. Distance (D) Achievement for Uniform Precision Combination Designs with Radial Versus Interior Pentagons

Table 12. Distance (D) and Response (R) Achievement for Orthogonal Designs

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
5	5	.000	D	.20886	.17868	.20773	.19896	.53203	.71468	.34016	Center Points
			R	.89848	.90532	.90587	.90928	.87151	.87318	.89394	
	6	.204	D	.23285	.19876	.22661	.42125	.38805	.26589	.28890	
			R	.89570	.90517	.90128	.88126	.84906	.87737	.88497	
	7	.267	D	.28949	.18804	.35663	.57526	.26260	.26026	.32205	
			R	.88747	.89857	.88215	.82551	.87552	.85759	.87114	
	8	.304	D	.36576	.21146	.21403	.27078	1.18130	1.26082	.58403	
			R	.88474	.89326	.89779	.89066	.84717	.78883	.86707	
	9	.330	D	.42978	.19170	.24993	.23876	.31726	.82822	.37594	
			R	.88470	.89063	.89320	.89006	.87850	.83027	.87789	
	10	.348	D	.44283	.18870	.20680	.26774	.41592	1.45325	.49587	
			R	.88198	.89004	.89439	.87415	.85943	.76542	.86090	
6	6	.000	D	.35643	.53235	.32173	.34171	.39284	.79841	.45725	Center Points
			R	.91273	.88527	.89725	.89442	.87167	.81816	.87992	
	7	.189	D	1.96130	.80166	.43259	.47982	.40180	.49533	.76208	
			R	.91688	.89539	.87875	.89724	.88605	.86045	.88913	
	8	.250	D	.40348	.81806	.45280	.45635	.42682	.51057	.51135	
			R	.91856	.89429	.87781	.89586	.88239	.85425	.88719	
	9	.287	D	.29003	.44034	3.12861	.69551	.44802	.49995	.91708	
			R	.91895	.89255	.81129	.88052	.87607	.85835	.87295	
	10	.314	D	.25244	.39620	2.20645	1.14886	.41282	.41430	.80518	
			R	.91857	.91186	.82454	.87967	.87507	.85499	.87745	
7	7	.000	D	.23230	.35285	.33629	.35867	.44116	.92768	.44149	Center Points
			R	.91268	.87792	.87597	.86942	.82576	.76523	.85450	

Table 12. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
7	8	.176	D	.22856	.38896	.34222	.40664	.76698	1.00882	.52370	
			R	.91219	.87258	.88132	.86792	.82467	.76372	.85373	
	9	.235	D	.23184	3.27039	.38135	.68129	.59979	.98944	1.02568	
			R	.90945	.87229	.88232	.86762	.82281	.76077	.85254	
	10	.273	D	.24110	.62858	.38719	.64470	.83082	3.94874	1.11352	
			R	.90549	.87195	.87527	.85362	.80256	.73180	.84012	
8	8	.000	D	.22013	.40307	.33326	.41561	1.02726	.77859	.52965	Center Points
			R	.91756	.89353	.87777	.85816	.82587	.77336	.85771	
	9	.167	D	.21223	.44648	.35406	.41321	1.43192	.86797	.62098	
			R	.92055	.88779	.87803	.85284	.80846	.73966	.84789	
	10	.223	D	.20884	.62125	.38582	1.18015	.42472	1.10431	.65418	
			R	.92248	.89427	.88026	.85669	.81371	.75603	.85391	
9	9	.000	D	.21997	20.45302	.77091	.44755	.54126	1.06284	3.91592	Center Points
			R	.91862	.89703	.87286	.83675	.80358	.75828	.84785	
	10	.158	D	.21276	.28469	.42191	.51274	.41589	.43018	.37970	
			R	.92112	.91103	.88379	.85352	.82553	.79356	.86476	
10	10	.000	D	.21990	.30356	.60134	.61624	.51594	.42173	.44645	Center Points
			R	.91861	.91314	.86859	.87262	.84596	.80943	.87139	
--	--	CCD	D	.22006	.26912	.87281	.74201	.76577	.77383	.60727	CCD
			R	.91756	.91014	.83659	.84382	.81905	.75745	.84744	

The best performances in this group are provided by two of the pentagon designs. The center point configuration of the orthogonal pentagon gave the best R achievement, and the pentagon with interior hexagon gave the best D achievement. As in the uniform precision case, both of these designs performed considerably better than the central composite design. It can also be seen again in this group that pentagon and hexagon designs perform generally better than larger designs with the same interior sets, although the distinction is not always as clear in this group as it was among uniform precision designs. This is shown graphically in Figure 5.

4.2.4 Minimum Bias Designs

Table 13 shows the performance achievements for all minimum bias designs, including six center point cases, 36 equiradial combination cases, and the central composite case.

The best performances in this group, as in the other groups, were achieved by pentagon and hexagon designs. The best response achievement was given by the hexagon augmented by two center points. The equiradial combination of a pentagon inside a pentagon gave a slightly better distance achievement, but a much poorer response achievement.

Once again, the pentagon and hexagon consistently out performed larger designs of similar configuration, and the best combination designs were those with $n_2 > n_1$. These results are shown in Figures 6 and 7.

4.2.5 "Best Performers"

Table 14 and Figure 8 show a summary of the best performing designs from each of the preceding groups. Since all of these were equiradial designs, the three central composite designs considered are also included

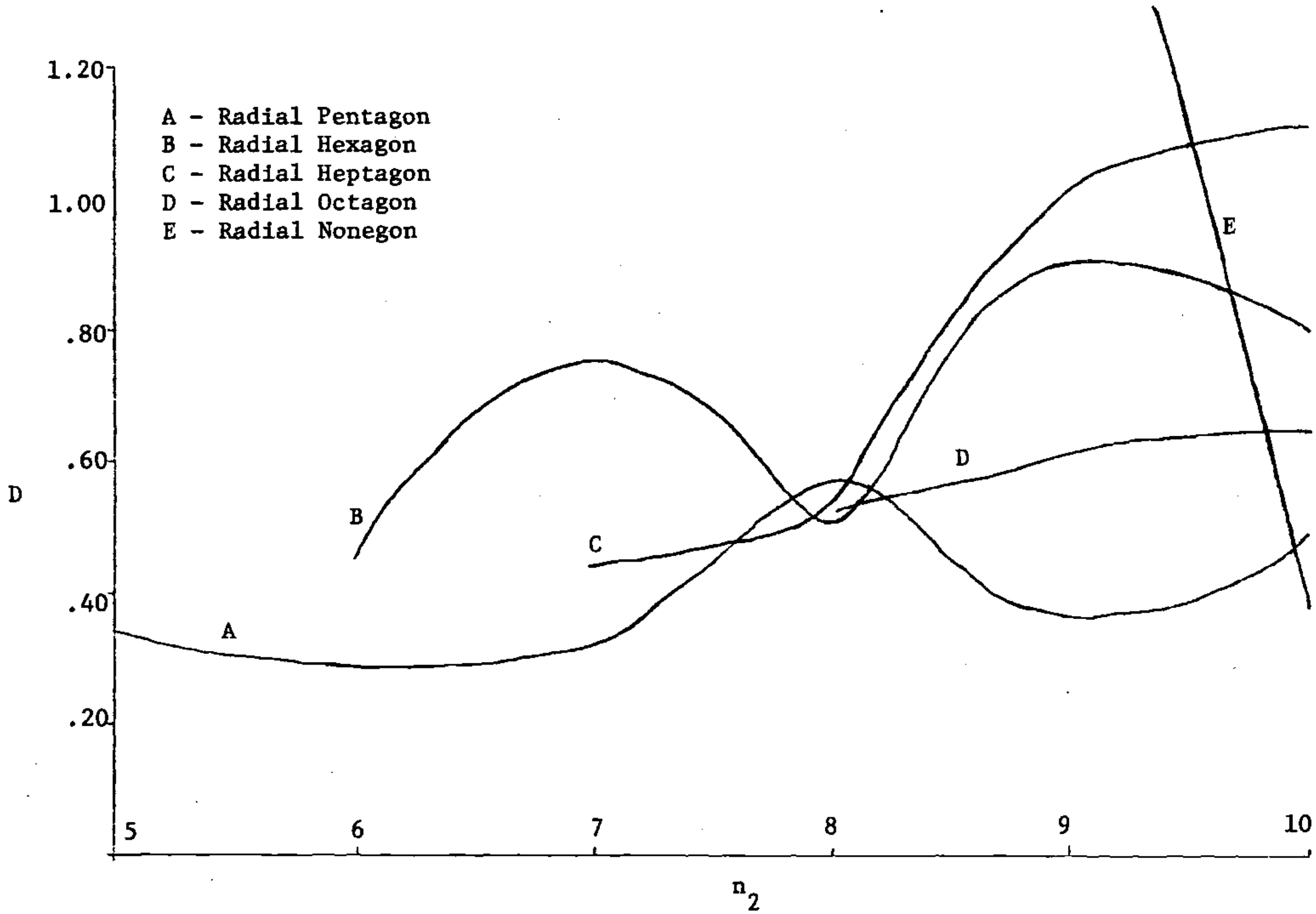

Figure 5. Distance (D) Achievement for Orthogonal Combination Designs with Various Interior Equiradial Sets

Table 13. Distance (D) and Response (R) Achievement for Minimum Bias Designs

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
5	1	.000	D	.20886	.22227	.37046	1.16629	.67986	.35625	.50067	Center Points
			R	.89848	.90559	.90945	.91161	.91117	.90289	.90653	
	5	.581	D	.22230	.26293	.30122	.23974	.31482	.48988	.30515	
			R	.86661	.87394	.88466	.89063	.88550	.86369	.87750	
	6	.597	D	.26234	.33121	.34293	1.14951	.56656	.54690	.53324	
			R	.86604	.88040	.88710	.87607	.86864	.86418	.87374	
	7	.607	D	.30938	1.57676	.38433	1.74427	.56598	.71587	.88276	
			R	.86095	.87349	.87996	.87321	.86314	.85620	.86782	
	8	.614	D	.54199	.85541	.83647	.87519	.55989	.44120	.68503	
			R	.85479	.86775	.85822	.85948	.85919	.85944	.85981	
	9	.618	D	1.50289	.86947	5.82923	.54067	.48328	.44565	1.61186	
			R	.84956	.85464	.87418	.89175	.89771	.89723	.87751	
	10	.620	D	.92969	.66572	.56271	.48035	.44725	.48945	.59586	
			R	.84389	.85982	.87215	.88419	.88583	.89071	.87277	
6	2	.000	D	.35641	.23676	.32523	.49703	.26240	.26807	.32432	Center Points
			R	.91273	.92592	.92523	.92181	.91760	.91321	.91942	
	5	.560	D	.30405	1.00728	.62236	.67204	.49711	.43903	.59031	
			R	.87738	.87520	.84372	.86805	.85776	.82444	.85776	
	6	.581	D	1.33722	.63722	.40496	.70504	2.35223	2.01375	1.24174	
			R	.88477	.85024	.85214	.82802	.80113	.76156	.82964	
	7	.595	D	.40585	.47091	.68207	1.72175	4.39966	3.86369	1.92399	
			R	.88886	.89754	.88771	.76229	.68311	.71017	.80495	

Table 13. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
6	8	.604	D	.32133	.27511	.75652	.85780	.51527	.42476	.52513	
			R	.88803	.90193	.90037	.89937	.88663	.87309	.89157	
	9	.611	D	.40232	.29627	.30467	1.75401	.36454	.41385	.58928	
			R	.88861	.90377	.90776	.89671	.89049	.86877	.89269	
	10	.615	D	.24613	.58931	.37594	.44178	.58812	1.29733	.58977	
			R	.89276	.90132	.90182	.86857	.83808	.73427	.85614	
7	2	.000	D	.23230	.45359	1.99721	2.48976	1.63027	.81217	1.26922	Center Points
			R	.91268	.91430	.79214	.73536	.79179	.80286	.82485	
	5	.537	D	.30297	.66928	.97826	1.95662	.71570	1.22093	.97396	
			R	.89719	.84850	.82468	.75156	.70302	.66406	.78150	
	6	.563	D	.31861	.32094	.46231	.93393	12.66450	.66424	2.56076	
			R	.89390	.87136	.82368	.78369	.74343	.71835	.80574	
	7	.581	D	1.29916	.36018	1.06864	.40087	.55965	2.46331	1.02530	
			R	.88944	.85526	.83369	.83169	.77301	.73194	.81917	
	8	.593	D	.29354	.36617	3.94349	.58394	.88159	1.43925	1.25133	
			R	.89661	.87723	.82415	.80542	.76816	.73635	.81799	
	9	.602	D	.29905	.41356	.81775	.66108	1.10188	.60088	.64904	
			R	.89690	.86246	.81992	.79793	.75978	.73398	.81183	
	10	.608	D	.29845	.47551	.67180	1.42092	.60808	1.36779	.80709	
			R	.89939	.83768	.80619	.77895	.74522	.70578	.79554	
8	2	.000	D	.22013	.37447	.47941	.84407	1.62640	1.44613	.83177	Center Points
			R	.91756	.88308	.85836	.73911	.58475	.60835	.76520	

Table 13. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
8	5	.513	D	.35051	.88788	.57607	.53491	5.03161	1.10313	1.41402	
			R	.90341	.85485	.82036	.75913	.67836	.61948	.77260	
	6	.545	D	.21718	.35564	2.35298	.53966	3.01705	1.39529	1.31297	
			R	.91556	.87005	.82877	.75635	.66654	.58260	.76996	
	7	.566	D	.23198	.29965	.63218	2.13299	.91248	1.44099	.94171	
			R	.91214	.87469	.83005	.77355	.68389	.61271	.78117	
	8	.581	D	.21506	.29318	.41934	.86753	.65479	1.38928	.63986	
			R	.91329	.87600	.82364	.77809	.72905	.68724	.80122	
	9	.592	D	.21163	.40259	.49984	1.09105	1.49494	3.28756	1.16460	
			R	.91938	.85929	.80019	.75480	.68536	.60573	.77079	
	10	.560	D	.21825	.37418	.49340	.90678	.51136	1.47173	.66262	
			R	.91785	.85845	.80731	.75785	.72995	.68737	.79313	
9	2	.000	D	.21997	1.13358	.55306	1.07063	2.57669	1.21563	1.12826	Center Points
			R	.91862	.81178	.79560	.59917	.55717	.58265	.71083	
	5	.488	D	.36324	.29772	.55330	2.14029	4.89869	2.89077	1.85734	
			R	.92369	.88759	.75816	.72179	.61338	.64203	.75777	
	6	.525	D	.21072	1.65128	.60917	1.23479	.68113	4.96055	1.55794	
			R	.92359	.86354	.78003	.73406	.70380	.61092	.76932	
	7	.550	D	.27852	2.43588	.88698	2.34281	.71241	1.26718	1.32063	
			R	.89697	.88334	.80658	.67894	.71062	.65190	.77139	
	8	.568	D	.23208	.36346	.61467	.83290	.89311	15.87416	3.13506	
			R	.90338	.87551	.78837	.70902	.64984	.59744	.75393	
	9	.581	D	.22337	.29783	2.17575	4.97808	.96659	3.93374	2.09573	
			R	.91068	.88074	.81365	.69435	.67728	.62903	.76762	

Table 13. (Continued)

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
9	10	.591	D	.24247	.26519	.36012	5.00554	.51163	.56579	1.15845	
			R	.90435	.89102	.84151	.79078	.74102	.69173	.81007	
10	3	.000	D	.21990	.35664	.87498	.41219	.76165	.47474	.51669	Center Points
			R	.91861	.90598	.88070	.86891	.83205	.76979	.86267	
	5	.462	D	.79204	.36074	.36717	.53101	.87756	.55883	.58123	
			R	.92351	.91413	.89496	.80263	.74487	.74449	.83743	
	6	.505	D	.21987	.64853	.45182	1.65271	.38825	.44030	.63358	
			R	.92478	.90669	.87179	.76786	.81865	.78033	.84502	
	7	.534	D	.20363	1.18650	1.23455	.34233	.47679	2.59240	1.00603	
			R	.92404	.81420	.82887	.83949	.74364	.68039	.80510	
	8	.554	D	.32332	3.91808	2.82684	.36637	.36489	.65217	1.40861	
			R	.89324	.82646	.87328	.85564	.81035	.71047	.82824	
	9	.569	D	.25069	.44319	.51534	2.36629	.58099	.37540	.75532	
			R	.90487	.89685	.87323	.85403	.83745	.83489	.86689	
	10	.581	D	.23219	.27974	.90946	.49351	1.02912	.57291	.58616	
			R	.90610	.90190	.85170	.87262	.83405	.82555	.86532	
--	--	CCD	D	.22006	.51976	.37006	1.25218	1.19974	.75740	.71987	CCD
			R	.91757	.87166	.85644	.64454	.58832	.71170	.76504	

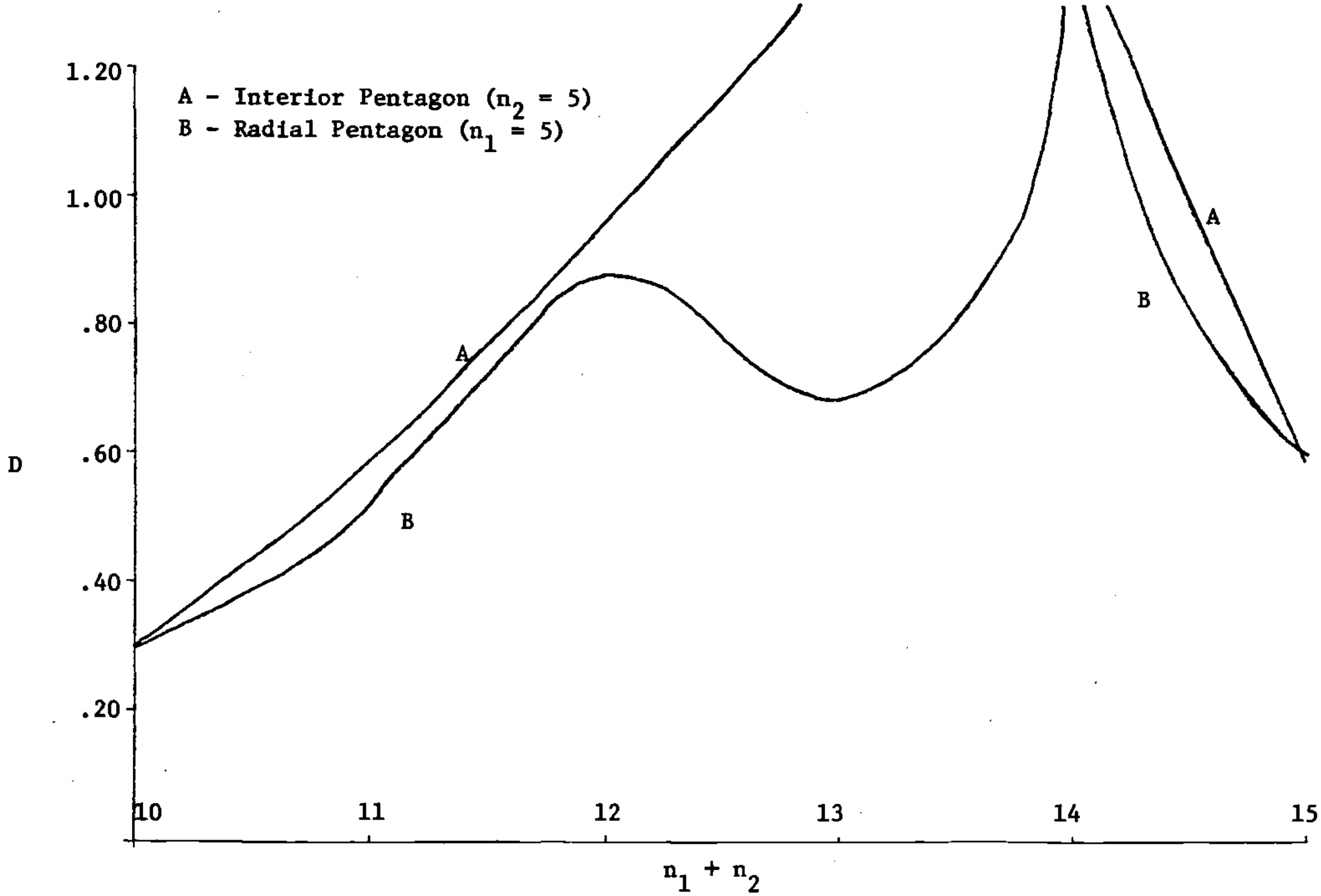

Figure 6. Distance (D) Achievement for Minimum Bias Combination Designs with Radial Versus Interior Pentagons

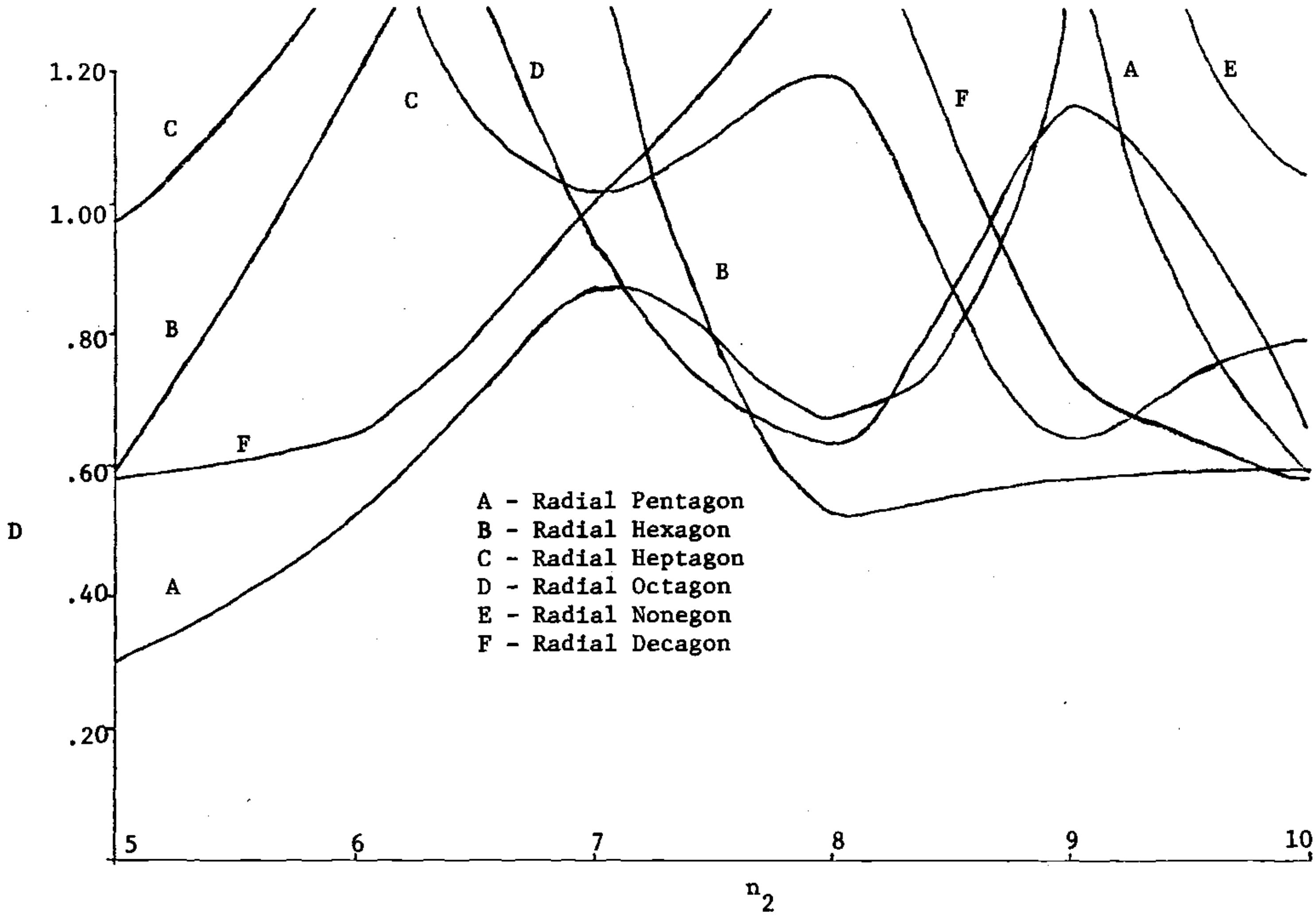

Figure 7. Distance (D) Achievement for Minimum Bias Combination Designs with Various Interior Equiradial Sets

Table 14. Distance (D) and Response (R) Summary for "Best Performers"

n_1	n_2	ρ_2/ρ_1	σ_ε	0.00	0.03	0.06	0.09	0.12	0.15	Avg	Remarks
5	3	.000	D	.20886	.17828	.19105	.19817	.18536	.21288	.19577	Unif Prec
			R	.89848	.90708	.90230	.90146	.91495	.90575	.90500	Center Points
6	3	.000	D	.35641	.24143	.46032	.25932	.31836	.29018	.32100	Unif Prec
			R	.91273	.92499	.92566	.92346	.92026	.91669	.92063	Center Points
5	5	.000	D	.20886	.17868	.20773	.19896	.53203	.71468	.34016	Orthogonal
			R	.89848	.90532	.90587	.90928	.87151	.87318	.89394	Center Points
5	6	.204	D	.23285	.19876	.22661	.42125	.38805	.26589	.28890	Orthogonal
			R	.89570	.90517	.90128	.88126	.84906	.87737	.88497	Combination
6	2	.000	D	.35641	.23676	.32523	.49703	.26240	.26807	.32432	Min Bias
			R	.91273	.92592	.92523	.92181	.91760	.91321	.91942	Center Points
5	5	.581	D	.22230	.26293	.30122	.23974	.31482	.48988	.30515	Min Bias
			R	.86661	.87394	.88466	.89063	.88550	.86369	.87750	Combination
--	--	CCD	D	.22006	.25483	.31944	1.21097	.77591	.44144	.53711	Unif Prec
			R	.91756	.91905	.91525	.84334	.79089	.88840	.87908	CCD
--	--	CCD	D	.22006	.26912	.87281	.74201	.76577	.77383	.60727	Orthogonal
			R	.91756	.91014	.83659	.84382	.81905	.75745	.84744	CCD
--	--	CCD	D	.22006	.59176	.37006	1.25218	1.19974	.75740	.71987	Min Bias
			R	.91757	.87166	.85644	.64454	.58832	.71170	.76504	CCD

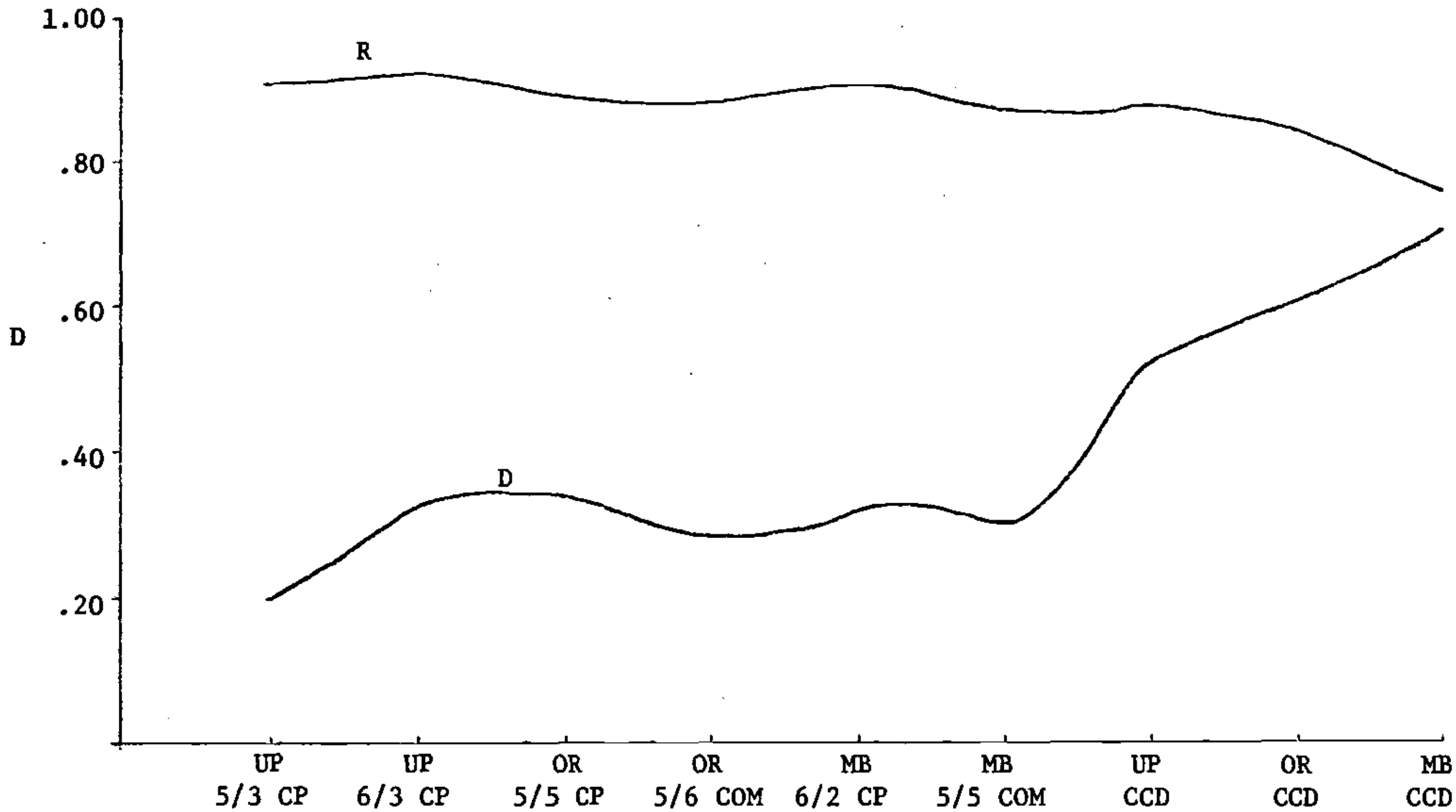

Figure 8. Average Distance (D) and Response (R) Achievement for "Best Performers"

for a final comparison. Clearly the best of this group are the uniform precision pentagon and hexagon. In the case of no experimental error, the performance of all designs in the group is closely similar.

4.3 Discussion

The underlying reasons for several of the observed results are not clearly apparent, but the possible causes are worth discussing. It was seen that designs derived from pentagons and hexagons consistently outperformed designs derived from larger equiradial sets. The reason for this cannot be stated conclusively; however, it may be related to the distribution of design points over the region of interest. The design points of pentagon and hexagon designs are distributed rather evenly over the entire region of interest. On the other hand, as the size of the equiradial set increases the distribution of design points becomes more heavily weighted toward the periphery of the region of interest. This weighting effect could also explain the observation that equiradial combination designs perform best when configured such that $n_2 > n_1$. It was also observed that the best designs among those derived from equiradial pentagons and hexagons were the uniform precision designs. This is intuitively agreeable with the development of the uniform precision criteria. The moderate value of λ_4 for these designs does not admit heavy bias effects, hence, performance should be comparable to that of minimum bias designs. Moreover, the uniform precision criterion implies that variance of the predictor is constant across the region of investigation. Since the true optimum was within this region for all designs considered, the results should be anticipated.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Several conclusions can be drawn from this investigation. The best designs of the equiradial class are those derived from equiradial pentagons and hexagons. These constitute a valuable group of designs which generally outperform the more widely used central composite designs. Among designs derived from equiradial pentagons and hexagons, the best are the uniform precision designs. In designs constructed by the combination of equiradial sets, the best configuration is for the set with the largest number of points to be the interior set.

5.2 Recommendations

The results of this study indicate that further study of the class of equiradial designs would be of value. In the case of equiradial designs in two variables, design generation was easily accomplished by applying a simple trigonometric relationship. For the case of more than two variables, design construction becomes more complicated. The only equiradial designs for k greater than two which are found in the literature are the icosahedron and the dodecahedron (see Box and Hunter (3)), both for three variables. Box and Hunter point out that in five or more dimensions there are only three regular figures. They show that second order rotatable designs can be obtained by combining two of these figures, the cross-polytope and the hypercube. The resulting design can be seen to be a member of the central composite class, however. Further investigation is recommended into the construction and performance of equiradial experimental designs for three and four variables.

APPENDICES

APPENDIX A

REPRESENTATIVE DESIGN AND MOMENT MATRICES

Uniform Precision Pentagon

$$D = \begin{bmatrix} .921 & .000 \\ .285 & .876 \\ -.745 & .541 \\ -.745 & -.541 \\ .285 & -.876 \\ .000 & .000 \\ .000 & .000 \\ .000 & .000 \end{bmatrix}$$

$$N^{-1}(X'X) = \begin{bmatrix} 1.000 & .000 & .000 & .265 & .265 & .000 \\ .000 & .265 & .000 & .000 & .000 & .000 \\ .000 & .000 & .265 & .000 & .000 & .000 \\ .265 & .000 & .000 & .169 & .056 & .000 \\ .265 & .000 & .000 & .056 & .169 & .000 \\ .000 & .000 & .000 & .000 & .000 & .056 \end{bmatrix}$$

Uniform Precision Hexagon

$$D = \begin{bmatrix} .892 & .000 \\ .446 & .773 \\ -.446 & .772 \\ -.892 & .000 \\ -.446 & -.773 \\ .446 & -.772 \\ .000 & .000 \\ .000 & .000 \\ .000 & .000 \end{bmatrix}$$

$$N^{-1}(X'X) = \begin{bmatrix} 1.000 & .000 & .000 & .265 & .265 & .000 \\ .000 & .265 & .000 & .000 & .000 & .000 \\ .000 & .000 & .265 & .000 & .000 & .000 \\ .265 & .000 & .000 & .158 & .053 & .000 \\ .265 & .000 & .000 & .053 & .158 & .000 \\ .000 & .000 & .000 & .000 & .000 & .053 \end{bmatrix}$$

<u>Orthogonal Pentagon</u>

$$D = \begin{bmatrix} 1.030 & .000 \\ .318 & .980 \\ -.833 & .605 \\ -.833 & -.605 \\ .318 & -.980 \\ .000 & .000 \\ .000 & .000 \\ .000 & .000 \\ .000 & .000 \\ .000 & .000 \end{bmatrix}$$

$$N^{-1}(X'X) = \begin{bmatrix} 1.000 & .000 & .000 & .265 & .265 & .000 \\ .000 & .265 & .000 & .000 & .000 & .000 \\ .000 & .000 & .265 & .000 & .000 & .000 \\ .265 & .000 & .000 & .211 & .070 & .000 \\ .265 & .000 & .000 & .070 & .211 & .000 \\ .000 & .000 & .000 & .000 & .000 & .070 \end{bmatrix}$$

Orthogonal Combination: Radial Pentagon/Interior Hexagon

$$D = \begin{bmatrix} 1.054 & .000 \\ .326 & 1.003 \\ -.853 & .620 \\ -.853 & -.620 \\ .326 & -1.003 \\ .215 & .000 \\ .107 & .186 \\ -.107 & .186 \\ -.215 & .000 \\ -.107 & -.186 \\ .107 & -.186 \end{bmatrix}$$

$$N^{-1}(X'X) = \begin{bmatrix} 1.000 & .000 & .000 & .265 & .265 & .000 \\ .000 & .265 & .000 & .000 & .000 & .000 \\ .000 & .000 & .265 & .000 & .000 & .000 \\ .265 & .000 & .000 & .211 & .070 & .000 \\ .265 & .000 & .000 & .070 & .211 & .000 \\ .000 & .000 & .000 & .000 & .000 & .070 \end{bmatrix}$$

Minimum Bias Hexagon

$$D = \begin{bmatrix} .841 & .000 \\ .420 & .728 \\ -.421 & .728 \\ -.841 & .000 \\ -.420 & -.728 \\ .421 & -.728 \\ .000 & .000 \\ .000 & .000 \end{bmatrix}$$

$$N^{-1}(X'X) = \begin{bmatrix} 1.000 & .000 & .000 & .265 & .265 & .000 \\ .000 & .265 & .000 & .000 & .000 & .000 \\ .000 & .000 & .265 & .000 & .000 & .000 \\ .265 & .000 & .000 & .141 & .047 & .000 \\ .265 & .000 & .000 & .047 & .141 & .000 \\ .000 & .000 & .000 & .000 & .000 & .047 \end{bmatrix}$$

<u>Minimum Bias Combination: Radial Pentagon/Interior Pentagon</u>

$$D = \begin{bmatrix} .891 & .000 \\ .275 & .847 \\ -.720 & .523 \\ -.720 & -.523 \\ .275 & -.847 \\ .517 & .000 \\ .160 & .492 \\ -.419 & .304 \\ -.419 & -.304 \\ .160 & -.492 \end{bmatrix}$$

$$N^{-1}(X'X) = \begin{bmatrix} 1.000 & .000 & .000 & .265 & .265 & .000 \\ .000 & .265 & .000 & .000 & .000 & .000 \\ .000 & .000 & .265 & .000 & .000 & .000 \\ .265 & .000 & .000 & .131 & .044 & .000 \\ .265 & .000 & .000 & .044 & .131 & .000 \\ .000 & .000 & .000 & .000 & .000 & .044 \end{bmatrix}$$

APPENDIX B

COMPUTER PROGRAM LISTING

```
      DIMENSION X(20,6),XP(6,20),XPX(6,6),XPXIXP(6,20),V(2),CP(30,3,2),
     1DP(20,2),YV(20),Y1(20,1),BETA(6,1),BV(2,1),BM(2,2),SP(1,2),R(20),
     2BMIBV(2,1),SPD(30,16),RESP(30,16),ASPD(6,16),ARESP(6,16),TASPD(16),
     3TARESP(16),MC(1),JC(6),RAT(10,10)
      READ(5,7)(((CP(I,J,K),I=1,30),J=1,3),K=1,2)
    7 FORMAT(10F8.5)
      R(1)=5425.0
      RAT(5,5)=0.000
      RAT(5,6)=0.2039
      RAT(5,7)=0.2663
      RAT(5,8)=0.3041
      RAT(5,9)=0.3293
      RAT(5,10)=0.3433
      RAT(6,6)=0.000
      RAT(6,7)=0.169
      RAT(6,8)=0.250
      RAT(6,9)=0.2872
      RAT(6,10)=0.3137
      RAT(7,7)=0.000
      RAT(7,8)=0.176
      RAT(7,9)=0.2352
      RAT(7,10)=0.2728
      RAT(8,8)=0.000
      RAT(8,9)=0.1666
      RAT(8,10)=0.2233
      RAT(9,9)=0.000
      RAT(9,10)=0.1581
      RAT(10,10)=0.000
      R(1)=5425.0
      DO 400 INV=5,10
      NV=INV
      DO 400 INCP=NV,10
      NCP=INCP
      NP=NV+NCP
      RATIO=RAT(NV,NCP)
      RHO=SQRT(.53045*NP/(NV+NCP*RATIO**2.))
      CF=RHO/.99
      NVO=NV+1
      DO 100 I=1,NV
      X(I,1)=1.
      X(I,2)=RHO*COS(6.2834*(I-1)/NV)
      X(I,3)=RHO*SIN(6.2834*(I-1)/NV)
      X(I,4)=X(I,2)**2.
      X(I,5)=X(I,3)**2.
      X(I,6)=X(I,2)*X(I,3)
  100 CONTINUE
      WRITE(6,10)NV,NCP,RATIO
   10 FORMAT(1H1,///,T17,'ORTHOGONAL COMBINATION DESIGN: ',
     1I2,' RADIAL AND ',1I2,' INNER VERTICES R2/R1=',1F5.3,/,
     2T15,'SURFACE\ERR ST DEV',T36,'0.00',T46,'0.03',
     3T56,'0.06',T66,'0.09',T76,'0.12',T86,'0.15',T96,'AVERAGE')
      DO 101 I=NVO,NP
      X(I,1)=1.
      X(I,2)=RATIO*RHO*COS(6.2834*(I-NVO)/NCP)
      X(I,3)=RATIO*RHO*SIN(6.2834*(I-NVO)/NCP)
      X(I,4)=X(I,2)**2.
      X(I,5)=X(I,3)**2.
      X(I,6)=X(I,2)*X(I,3)
  101 CONTINUE
      DO 102 I=1,NP
      DO 102 J=1,6
      XP(J,I)=X(I,J)
  102 CONTINUE
      CALL MXMLT(XP,X,XPX,6,NP,6,6,20)
      V(1)=1.0
      CALL GJR(XPX,6,6,6,MC,$1,JC,V)
      CALL MXMLT(XPX,XP,XPXIXP,6,6,NP,6,6)
      DO 207 NSURF=1,6
      DO 203 ICP=1,30
      IF(NSURF.LE.2.OR.NSURF.EQ.4) IS=1
      IF(NSURF.EQ.3.OR.NSURF.EQ.5) IS=2
      IF(NSURF.EQ.6) IS=3
      DCX1=CP(ICP,IS,1)
      DCX2=CP(ICP,IS,2)
      DO 200 I=1,NP
      DP(I,1)=X(I,2)/CF+DCX1
      DP(I,2)=X(I,3)/CF+DCX2
  200 CONTINUE
      CALL SURF(NSURF,DP,YV,NP,20,20)
      DO 203 IE=1,16,3
      ERR=(IE-1)/100.
      IF(IE-1)3,3,4
    3 DO 213 I=1,NP
      Y1(I,1)=YV(I)
  213 CONTINUE
      GO TO 212
    4 CALL RANDN(R,NP,0.0,ERR)
      DO 202 I=1,NP
      Y1(I,1)=YV(I)+R(I)
  202 CONTINUE
      R(1)=R(NP)
  212 CALL MXMLT(XPXIXP,Y1,BETA,6,NP,1,6,20)
      BV(1,1)=BETA(2,1)
      BV(2,1)=BETA(3,1)
      BM(1,1)=BETA(4,1)
      BM(2,2)=BETA(5,1)
      BM(1,2)=BETA(6,1)/2.
      BM(2,1)=BM(1,2)
      V(1)=1.0
      CALL GJR(BM,2,2,2,MC,$1,JC,V)
      CALL MXMLT(BM,BV,BMIBV,2,2,1,2,2)
      SP(1,1)=-BMIBV(1,1)/(2.*CF)+DCX1
      SP(1,2)=-BMIBV(2,1)/(2.*CF)+DCX2
      IF(NSURF.LE.5) SPD(ICP,IE)=((SP(1,1)-1.)**2.+(SP(1,2)-1.)**2.)**.5
      IF(NSURF.EQ.6) SPD(ICP,IE)=((SP(1,1)-2.4475)**2.+(SP(1,2)-3.8875)
     1**2.)**.5
```

```
      CALL SURF(NSURF,SP,AR,1,1,1)
      IF(NSURF.LE.4) RESP(ICP,IL)=AR(1)
      IF(NSURF.EQ.5) RESP(ICP,IL)=1./ABS(AR(1))
      IF(NSURF.EQ.6) RESP(ICP,IL)=AR(1)/4.173749909
  203 CONTINUE
      DO 205 I=1,16,3
      TSPD=0.0
      TRESP=0.0
      DO 204 J=1,30
      TSPD=TSPD+SPD(J,I)
      TRESP=TRESP+RESP(J,I)
  204 CONTINUE
      ASPD(NSURF,I)=TSPD/30.0
      ARESP(NSURF,I)=TRESP/30.0
  205 CONTINUE
      TSPD=0.0
      TRESP=0.0
      DO 206 I=1,16,3
      TSPD=TSPD+ASPD(NSURF,I)
      TRESP=TRESP+ARESP(NSURF,I)
  206 CONTINUE
      OASPD=TSPD/6.0
      OARESP=TRESP/6.0
      WRITE(6,5)NSURF,(ASPD(NSURF,I),I=1,16,3),OASPD,(ARESP(NSURF
     1,I),I=1,16,3),OARESP
  207 CONTINUE
      TOAS=0.0
      TOAR=0.0
      DO 301 I=1,16,3
      TSPD=0.0
      TRESP=0.0
      DO 300 J=1,6
      TSPD=TSPD+ASPD(J,I)
      TRESP=TRESP+ARESP(J,I)
  300 CONTINUE
      TASPD(I)=TSPD/6.0
      TARESP(I)=TRESP/6.0
      TOAS=TOAS+TASPD(I)
      TOAR=TOAR+TARESP(I)
  301 CONTINUE
      TOAS=TOAS/6.0
      TOAR=TOAR/6.0
      WRITE(6,6)(TASPD(I),I=1,16,3),TOAS,(TARESP(I),I=1,16,3),TOAR
    5 FORMAT(T19,I1,T25,'AVG SP DEV',T33,7F10.5,/,T25,'AVG RESP',
     1T33,7F10.5)
    6 FORMAT(T16,'ALL',T25,'AVG SP DEV',T33,7F10.5,/,T25,'AVG RESP',
     1T33,7F10.5)
      GO TO 400
    1 WRITE(6,2)
  400 CONTINUE
    2 FORMAT(1H0,T50,'SINGULAR MATRIX OR OVERFLOW ERROR')
      STOP
      END
```

```
      SUBROUTINE SURF(NSURF,A,B,IN,MA,MB)
      DIMENSION A(MA,2),B(MB)
      GO TO (1,2,3,4,5,6),NSURF
    1 DO 10 I=1,IN
      B(I)=(((.5+.5*A(I,1))**4.)*A(I,2)**4.)*EXP(2.-(.5+.5*A(I,1))**4.-
     1A(I,2)**4.)
   10 CONTINUE
      GO TO 7
    2 DO 20 I=1,IN
      B(I)=((.3+.4*A(I,1)+.3*A(I,2))**4.)+((.8-.6*A(I,1)+.8*A(I,2))**4./
     1*EXP(2.-(.3+.4*A(I,1)+.3*A(I,2))**4.-(.8-.6*A(I,1)+.8*A(I,2))**4./
   20 CONTINUE
      GO TO 7
    3 DO 30 I=1,IN
      B(I)=A(I,1)**2.*EXP(1.-A(I,1)**2.-20.25*(A(I,1)-A(I,2))**2.)
   30 CONTINUE
      GO TO 7
    4 DO 40 I=1,IN
      B(I)=(.3*A(I,1)**2.+.7*A(I,2)**2.)**3.*EXP(1.-.6*(A(I,1)-A(I,2))**
     12.-(.3*A(I,1)**2.+.7*A(I,2)**2.)**3.)
   40 CONTINUE
      GO TO 7
    5 DO 50 I=1,IN
      B(I)=-(1.+100.*(A(I,2)-A(I,1)**2.)**2.+(1.-A(I,1))**2.)
   50 CONTINUE
      GO TO 7
    6 DO 60 I=1,IN
      X=A(I,1)**2.
      Y=A(I,2)**2.
      Z=A(I,1)*A(I,2)
      B(I)=Z/(.9+.066*A(I,1)-.001*A(I,2)-.01*X+.03*Y+.005*Z+.01*X*A(I,2)
     1-.017*A(I,1)*Y+.015*Z**2.)
   60 CONTINUE
    7 CONTINUE
      RETURN
      END
```

APPENDIX C

INDIVIDUAL DESIGN PERFORMANCE DATA

EQUIRADIAL DESIGN: 5 VERTICES AND 1 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06375	.05602	.04377	.04344	.04676	.05229	.04999
	AVG RESP	.97272	.98630	.99348	.99341	.99067	.98652	.98752
2	AVG SP D	.05868	.05268	.05722	.06965	.08164	.09196	.06864
	AVG RESP	.97574	.98266	.98119	.97690	.97155	.96678	.97564
3	AVG SP D	.09987	.12246	.12815	.10023	.09995	.11709	.11129
	AVG RESP	.94375	.92659	.91659	.94130	.94126	.92958	.93515
4	AVG SP D	.61720	.58695	1.43651	6.18505	3.19941	1.15653	2.19761
	AVG RESP	.78586	.83280	.87267	.87677	.89524	.88258	.85762
5	AVG SP D	.38242	.40366	.42827	.45737	.49274	.53765	.45025
	AVG RESP	.71281	.70545	.69318	.68138	.66935	.65604	.68595
6	AVG SP D	.03125	.11583	.12886	.14199	.15864	.18669	.12621
	AVG RESP	.99998	.99976	.99962	.99937	.99894	.99824	.99932
ALL	AVG SP D	.20886	.22227	.37846	1.16629	.67986	.35625	.50067
	AVG RESP	.89848	.90559	.90945	.91161	.91117	.90269	.90653

EQUIRADIAL DESIGN: 5 VERTICES AND 2 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06375	.04483	.04019	.04510	.05410	.06653	.05188
	AVG RESP	.97272	.99162	.99434	.99078	.98489	.97629	.98544
2	AVG SP D	.05868	.05043	.05598	.06758	.07630	.08511	.06535
	AVG RESP	.97574	.98724	.98764	.98511	.98170	.97007	.98258
3	AVG SP D	.09987	.59906	.09645	.10566	.09781	.11199	.18514
	AVG RESP	.94375	.91620	.94234	.93645	.93955	.92682	.93451
4	AVG SP D	.61719	.27772	.50058	.78747	.23230	.16229	.42959
	AVG RESP	.78586	.83607	.86480	.81130	.88888	.94112	.85167
5	AVG SP D	.38242	.41257	.44967	.49730	.56197	.65698	.49348
	AVG RESP	.71281	.69937	.68422	.66692	.64620	.61677	.67105
6	AVG SP D	.03125	.11710	.12965	.13785	.14389	.14657	.11805
	AVG RESP	.99998	.99970	.99949	.99930	.99914	.99901	.99944
ALL	AVG SP D	.20886	.25029	.21209	.27349	.19440	.20458	.22392
	AVG RESP	.89848	.90536	.91214	.89831	.90339	.90701	.90412

EQUIRADIAL DESIGN: 5 VERTICES AND 3 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06375	.04460	.04135	.04834	.05871	.06602	.05422
	AVG RESP	.97272	.99208	.99401	.98958	.98297	.97563	.98453
2	AVG SP D	.05868	.05614	.05671	.06830	.07701	.08665	.06578
	AVG RESP	.97574	.98794	.98820	.98531	.98147	.97757	.98267
3	AVG SP D	.09987	.19689	.09541	.12579	.09262	.14918	.12663
	AVG RESP	.94375	.91726	.94260	.92157	.93988	.90941	.92908
4	AVG SP D	.61719	.24428	.36542	.29816	.15595	.12960	.30180
	AVG RESP	.78586	.84704	.80739	.84966	.94599	.96924	.86753
5	AVG SP D	.38242	.41456	.45467	.50719	.58057	.69398	.50557
	AVG RESP	.71281	.69647	.68220	.66345	.64034	.60670	.66683
6	AVG SP D	.03125	.11922	.13275	.14127	.14732	.15167	.12061
	AVG RESP	.99998	.99966	.99942	.99921	.99905	.99892	.99937
ALL	AVG SP D	.20886	.17628	.19105	.19817	.18536	.21268	.19577
	AVG RESP	.89848	.90708	.90230	.90146	.91495	.90575	.90503

EQUIRADIAL DESIGN: 5 VERTICES AND 4 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06375	.04550	.03953	.04217	.04946	.05770	.04968
	AVG RESP	.97272	.99197	.99452	.99186	.98672	.98673	.98627
2	AVG SP D	.05868	.05678	.05564	.06716	.07603	.08268	.06520
	AVG RESP	.97574	.98643	.98684	.98450	.98138	.97612	.98217
3	AVG SP D	.09987	.29955	.09835	.09963	.14158	.09510	.13901
	AVG RESP	.94375	.91609	.94139	.94081	.90952	.94648	.93201
4	AVG SP D	.61719	1.05989	.28763	.41798	1.76746	.27664	.73816
	AVG RESP	.78586	.93463	.88213	.80117	.81409	.84964	.82782
5	AVG SP D	.38242	.41657	.44476	.48780	.54469	.62469	.48249
	AVG RESP	.71281	.70027	.68622	.67634	.65173	.62733	.67478
6	AVG SP D	.03125	.11596	.12634	.13399	.13989	.14464	.11519
	AVG RESP	.99998	.99973	.99956	.99940	.99925	.99911	.99950
ALL	AVG SP D	.20886	.33023	.17539	.20812	.45318	.21597	.20496
	AVG RESP	.89848	.90470	.91511	.89801	.89645	.89560	.90043

EQUIRADIAL DESIGN: 5 VERTICES AND 5 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06375	.05232	.04914	.05119	.05740	.06600	.05681
	AVG RESP	.97272	.98667	.99177	.99185	.98876	.98632	.98585
2	AVG SP D	.05868	.05598	.06001	.07425	.09030	.10603	.07389
	AVG RESP	.97574	.98654	.97691	.96924	.95687	.94603	.96789
3	AVG SP D	.09987	.11565	.28179	.10990	.10201	.10612	.13589
	AVG RESP	.94375	.93298	.91499	.93304	.93692	.93650	.93330
4	AVG SP D	.61719	.72291	.25470	.22748	.22232	.25164	.31602
	AVG RESP	.78586	.82743	.95691	.88147	.88716	.87621	.85199
5	AVG SP D	.38242	.40679	.42168	.44580	.47422	.50649	.43890
	AVG RESP	.71281	.70479	.69606	.68655	.67614	.66460	.69016
6	AVG SP D	.03125	.12600	.17406	.28515	2.24596	3.25213	1.01942
	AVG RESP	.99998	.99964	.99874	.99352	.77921	.63561	.93445
ALL	AVG SP D	.20886	.17668	.20773	.19896	.53203	.71468	.34616
	AVG RESP	.89848	.90532	.90587	.90928	.87151	.87618	.89594

EQUIRADIAL DESIGN: 6 VERTICES AND 1 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03024	.03163	.04770	.06351	.07621	.08047	.05596
	AVG RESP	.98934	.99600	.99225	.98550	.97805	.97074	.98531
2	AVG SP D	.03894	.04851	.06132	.07201	.08115	.08803	.06509
	AVG RESP	.98731	.99093	.98871	.98490	.98053	.97598	.98473
3	AVG SP D	.19548	.10086	.08741	.08165	.08034	.08037	.10539
	AVG RESP	.93448	.95770	.95295	.94703	.94127	.93579	.94487
4	AVG SP D	.11540	.07146	.06891	.07962	.09127	.10123	.08798
	AVG RESP	.93320	.98142	.98763	.98348	.97605	.96705	.97160
5	AVG SP D	1.72977	1.02735	1.34169	11.81553	1.18118	1.00077	3.01705
	AVG RESP	.63207	.63092	.62971	.62836	.62077	.62492	.62879
6	AVG SP D	.02880	.13584	.15371	.16246	.16773	.17127	.13663
	AVG RESP	.99996	.99926	.99884	.99859	.99843	.99631	.99890
ALL	AVG SP D	.35644	.23094	.29346	2.04580	.27965	.25062	.57602
	AVG RESP	.91273	.92604	.92502	.92131	.91685	.91226	.91903

EQUIRADIAL DESIGN: 6 VERTICES AND 2 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03024	.03115	.04637	.06170	.07418	.08434	.05466
	AVG RESP	.98934	.99597	.99269	.98638	.97929	.97225	.98599
2	AVG SP D	.03894	.04635	.06099	.07121	.08015	.08749	.06452
	AVG RESP	.98731	.99071	.98867	.98516	.98111	.97667	.98497
3	AVG SP D	.19548	.10803	.08803	.08180	.08020	.08026	.10563
	AVG RESP	.93448	.95788	.95362	.94806	.94259	.93756	.94567
4	AVG SP D	.11540	.07257	.06832	.07854	.08986	.09979	.08741
	AVG RESP	.93320	.98072	.98771	.98415	.97713	.96917	.97201
5	AVG SP D	1.72959	1.02543	1.53429	2.52642	1.08196	1.08474	1.49707
	AVG RESP	.63207	.63097	.62981	.62853	.62703	.62529	.62895
6	AVG SP D	.02879	.13505	.15339	.16249	.16803	.17178	.13659
	AVG RESP	.99998	.99928	.99885	.99860	.99843	.99631	.99891
ALL	AVG SP D	.35641	.23676	.32523	.49703	.26240	.26007	.32432
	AVG RESP	.91273	.92592	.92523	.92181	.91760	.91521	.91942

EQUIRADIAL DESIGN: 6 VERTICES AND 3 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03024	.02977	.04191	.05506	.06668	.07654	.05003
	AVG RESP	.98934	.99555	.99392	.98942	.98386	.97603	.98836
2	AVG SP D	.03894	.04788	.06025	.06970	.07718	.08401	.06300
	AVG RESP	.98731	.98934	.98757	.98483	.98177	.97657	.98490
3	AVG SP D	.19548	.11408	.09162	.08310	.07991	.07900	.10720
	AVG RESP	.93448	.95645	.95650	.95263	.94856	.94431	.94919
4	AVG SP D	.11540	.08097	.07024	.07763	.08645	.09605	.08856
	AVG RESP	.93320	.97609	.98682	.98613	.98096	.97411	.97288
5	AVG SP D	1.72963	1.04153	2.33982	1.09895	1.41759	1.21021	1.47396
	AVG RESP	.63207	.63119	.63026	.62926	.62814	.62606	.62963
6	AVG SP D	.02879	.13434	.15808	.17147	.18032	.18604	.14327
	AVG RESP	.99998	.99935	.99886	.99851	.99825	.99605	.99883
ALL	AVG SP D	.35641	.24143	.46032	.25932	.31836	.29018	.32100
	AVG RESP	.91273	.92499	.92566	.92346	.92026	.91609	.92063

EQUIRADIAL DESIGN: 6 VERTICES AND 4 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03024	.03291	.04852	.06834	.09015	.11416	.06404
	AVG RESP	.98934	.99272	.99019	.98308	.97142	.95435	.98018
2	AVG SP D	.03894	.04645	.06322	.07710	.08988	.10198	.06993
	AVG RESP	.98731	.98478	.97905	.97137	.96201	.95092	.97257
3	AVG SP D	.19548	.13024	.10412	.09065	.08304	.07670	.11370
	AVG RESP	.93448	.95769	.96064	.96040	.95919	.95742	.95497
4	AVG SP D	.11540	.14682	.38918	.52419	.30118	.46030	.32188
	AVG RESP	.93320	.93044	.83921	.85450	.88344	.86948	.88505
5	AVG SP D	1.72964	1.23673	1.02813	1.64727	1.26379	1.15293	1.34308
	AVG RESP	.63207	.63160	.67119	.63056	.62998	.62936	.63078
6	AVG SP D	.02879	4.15939	4.06501	.64119	.41861	.35015	1.61052
	AVG RESP	.99998	.62632	.45699	.93963	.98232	.98673	.86565
ALL	AVG SP D	.35642	.95807	.94970	.50312	.37444	.37640	.58719
	AVG RESP	.91273	.88726	.80951	.88992	.89806	.89171	.88153

EQUIRADIAL DESIGN: 6 VERTICES AND 5 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03024	.03576	.05621	.08538	.12308	.17508	.08406
	AVG RESP	.98934	.99120	.98600	.97211	.94486	.89626	.96313
2	AVG SP D	.03894	.04903	.06559	.08239	.10067	.11952	.07611
	AVG RESP	.98731	.98282	.97402	.96117	.94370	.92035	.96159
3	AVG SP D	.19548	.13672	.11016	.09524	.08605	.08023	.11731
	AVG RESP	.93448	.95667	.96117	.96212	.96177	.96035	.95613
4	AVG SP D	.11540	.09525	.89205	.69171	.67166	.41610	.49769
	AVG RESP	.93320	.82252	.84856	.85717	.86839	.81052	.85673
5	AVG SP D	1.72971	1.39790	1.03117	1.12570	11.42857	1.17276	2.98097
	AVG RESP	.63207	.63172	.63134	.63093	.63049	.63001	.63110
6	AVG SP D	.02879	3.60039	.38756	.27797	.24651	.23221	.79557
	AVG RESP	.99998	.74049	.98787	.99436	.99558	.99607	.95239
ALL	AVG SP D	.35643	.91918	.42379	.37815	2.10942	.30475	.75662
	AVG RESP	.91273	.85424	.89816	.89631	.89080	.86663	.88684

EQUIRADIAL DESIGN: 6 VERTICES AND 0 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03624	.03883	.06532	.10722	.17137	.28108	.11570
	AVG RESP	.99634	.98970	.98081	.95563	.89676	.77434	.93110
2	AVG SP D	.03694	.04968	.06811	.08924	.11315	.14131	.08341
	AVG RESP	.98731	.98102	.96884	.94956	.92082	.87930	.94781
3	AVG SP D	.19548	.14265	.11616	.10022	.08975	.08268	.12116
	AVG RESP	.93448	.95546	.96115	.96309	.96342	.96250	.95668
4	AVG SP D	.11640	.63789	.34671	.49352	.45118	.98935	.50567
	AVG RESP	.93320	.81417	.84524	.87010	.82094	.66503	.82478
5	AVG SP D	1.72670	1.63282	1.06948	1.63505	1.32002	3.09019	1.64621
	AVG RESP	.63207	.63182	.63154	.63123	.63089	.63052	.63135
6	AVG SP D	.02479	.69226	.26459	.22503	.21159	.20528	.27125
	AVG RESP	.99998	.93942	.99595	.99691	.99716	.99727	.98778
ALL	AVG SP D	.35643	.53235	.32173	.34171	.39284	.79641	.45725
	AVG RESP	.91273	.88527	.89725	.89442	.87167	.81616	.87992

EQUIRADIAL DESIGN: 7 VERTICES AND 1 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.04277	.05737	.07159	.08432	.09615	.06434
	AVG RESP	.99826	.99140	.98799	.98225	.97549	.96624	.98228
2	AVG SP D	.03452	.04698	.06336	.07487	.08558	.09470	.06700
	AVG RESP	.98832	.98798	.98414	.97911	.97343	.96729	.98005
3	AVG SP D	.12660	.09133	.07499	.07437	.07572	.07750	.08675
	AVG RESP	.93486	.96307	.95955	.95289	.94579	.93621	.94906
4	AVG SP D	.12043	.08501	.08661	.10143	.11647	.12926	.10653
	AVG RESP	.93111	.96798	.97348	.97031	.96370	.95578	.96039
5	AVG SP D	1.04012	2.25110	1.08034	13.25455	1.07328	2.26625	3.49577
	AVG RESP	.63350	.63065	.62740	.62373	.61964	.61517	.62502
6	AVG SP D	.02826	.20368	.24249	.25978	.26963	.27600	.21331
	AVG RESP	.99998	.99676	.99813	.99760	.99759	.99745	.99829
ALL	AVG SP D	.23230	.45381	.26752	2.30610	.28417	.48961	.67228
	AVG RESP	.91268	.92531	.92178	.91768	.91261	.90762	.91585

EQUIRADIAL DESIGN: 7 VERTICES AND 2 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.04297	.05876	.07399	.08887	.10569	.06719
	AVG RESP	.99828	.98699	.98435	.97676	.96699	.95528	.97678
2	AVG SP D	.03452	.04654	.06349	.07591	.08665	.09653	.06761
	AVG RESP	.98832	.98493	.97886	.97133	.96258	.95262	.97311
3	AVG SP D	.12660	.12075	.07885	.07521	.07594	.07793	.09255
	AVG RESP	.93486	.94373	.96306	.95708	.94962	.94071	.94817
4	AVG SP D	.12043	.10627	.11138	.12690	.15123	.18674	.13416
	AVG RESP	.93111	.95442	.96026	.95660	.94483	.92515	.94539
5	AVG SP D	1.04012	1.25013	1.75107	1.08794	2.06759	1.18557	1.39854
	AVG RESP	.63350	.63074	.62771	.62439	.62079	.61694	.62568
6	AVG SP D	.02827	1.15286	9.91969	13.49860	7.31135	3.22676	5.85526
	AVG RESP	.99998	.98297	.23658	-.07401	.30596	.42647	.47999
ALL	AVG SP D	.23230	.45359	1.99721	2.48976	1.63027	.61217	1.20922
	AVG RESP	.91268	.91430	.79214	.73536	.79179	.60266	.82485

EQUIRADIAL DESIGN: 7 VERTICES AND 3 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.04966	.08184	.12842	.19765	.31557	.13463
	AVG RESP	.99828	.98068	.95892	.91230	.82530	.69260	.89301
2	AVG SP D	.03452	.05052	.07102	.09525	.12466	.16241	.08973
	AVG RESP	.98832	.97589	.95439	.92050	.87100	.80424	.91908
3	AVG SP D	.12660	.42001	.20500	.09943	.08980	.08955	.17173
	AVG RESP	.93486	.87684	.90657	.95364	.94192	.91954	.92256
4	AVG SP D	.12043	.40159	.51101	.56502	.67616	53.15107	9.23755
	AVG RESP	.93111	.79118	.81729	.79840	.67306	.51448	.75426
5	AVG SP D	1.04012	1.04260	1.07527	1.16122	1.35871	1.96657	1.27583
	AVG RESP	.63350	.63099	.62817	.62535	.62244	.61942	.62663
6	AVG SP D	.02827	.20179	.18475	.18368	.18484	.18635	.16161
	AVG RESP	.99996	.99909	.99903	.99887	.99872	.99860	.99905
ALL	AVG SP D	.23230	.36193	.35491	.37217	.43864	9.31214	1.64518
	AVG RESP	.91268	.87610	.87739	.86619	.82209	.75615	.85243

EQUIRADIAL DESIGN: 7 VERTICES AND 4 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.05249	.09166	.15454	.26645	.54997	.19166
	AVG RESP	.99826	.97830	.94876	.87361	.73879	.54613	.84848
2	AVG SP D	.03452	.05152	.07418	.10365	.14143	.19663	.10022
	AVG RESP	.98832	.97349	.94631	.90897	.83151	.73734	.89632
3	AVG SP D	.12660	.23178	.19559	.14538	.10506	.09969	.15033
	AVG RESP	.93486	.89212	.88659	.91649	.93253	.90690	.91058
4	AVG SP D	.12043	.91499	.50458	.47241	2.02482	3.92426	1.41023
	AVG RESP	.93111	.79691	.79637	.74832	.59741	.42735	.71628
5	AVG SP D	1.04012	1.04086	1.04400	1.05813	1.08426	1.12569	1.06691
	AVG RESP	.63350	.63091	.62826	.62553	.62273	.61967	.62680
6	AVG SP D	.02827	.17933	.16856	.16911	.17119	.17540	.14831
	AVG RESP	.99998	.99934	.99927	.99913	.99900	.99868	.99927
ALL	AVG SP D	.23230	.39514	.30608	.35644	.73226	1.01651	.51128
	AVG RESP	.91268	.87651	.86759	.84384	.78699	.70611	.83282

EQUIRADIAL DESIGN: 7 VERTICES AND 5 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.05597	.10125	.18531	.36120	13.23563	2.32825
	AVG RESP	.98828	.97018	.93659	.64121	.64530	.44512	.60578
2	AVG SP D	.03452	.05246	.07730	.11086	.15901	.23641	.11176
	AVG RESP	.98832	.97139	.93879	.68181	.79219	.67491	.87457
3	AVG SP D	.12660	.15652	.28561	.22301	.16795	.12235	.18067
	AVG RESP	.93486	.91188	.89836	.87587	.87015	.86662	.89632
4	AVG SP D	.12043	.42135	.43302	2.08835	1.97401	1837.10236	307.02325
	AVG RESP	.93111	.78971	.80330	.71267	.50795	.46610	.70214
5	AVG SP D	1.04912	1.04496	1.04245	1.04141	1.04178	1.04523	1.04381
	AVG RESP	.63350	.63093	.62832	.62567	.62297	.62022	.62693
6	AVG SP D	.02827	.16713	.15651	.15935	.16165	.16406	.13982
	AVG RESP	.99998	.99946	.99942	.99932	.99920	.99910	.99942
ALL	AVG SP D	.23230	.31058	.34969	.63438	.64425	308.65037	51.80459
	AVG RESP	.91268	.87993	.86780	.62276	.75962	.68258	.81753

EQUIRADIAL DESIGN: 7 VERTICES AND 6 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.04664	.07643	.11994	.17810	.26775	.12129
	AVG RESP	.98828	.98157	.96239	.92264	.85149	.74249	.90818
2	AVG SP D	.03452	.05017	.06995	.09259	.11915	.15162	.08637
	AVG RESP	.98832	.97680	.95739	.92736	.88439	.82692	.92685
3	AVG SP D	.12660	.23531	.14267	.09325	.08664	.08715	.12860
	AVG RESP	.93486	.88605	.92006	.95624	.94392	.92543	.92743
4	AVG SP D	.12043	1.56617	.37227	.39132	.56048	2.13548	.85636
	AVG RESP	.93111	.79508	.81031	.80007	.70734	.56106	.76730
5	AVG SP D	1.04912	1.04561	1.10016	1.25462	1.75465	45.23120	8.57256
	AVG RESP	.63350	.63097	.62814	.62528	.62232	.61924	.62656
6	AVG SP D	.02827	.21475	.19331	.19107	.19160	.19268	.16861
	AVG RESP	.99998	.99694	.99890	.99874	.99860	.99648	.99894
ALL	AVG SP D	.23230	.52578	.32613	.35713	.48177	8.01608	1.65563
	AVG RESP	.91268	.87788	.87952	.87176	.83467	.77674	.85921

EQUIRADIAL DESIGN: 7 VERTICES AND 7 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03486	.04938	.08087	.12598	.19190	.30676	.13062
	AVG RESP	.98828	.98093	.95991	.91536	.83298	.70719	.89744
2	AVG SP D	.03452	.05042	.07071	.09449	.12308	.15954	.08876
	AVG RESP	.98832	.97614	.95521	.92253	.87488	.81075	.92131
3	AVG SP D	.12660	.32624	.17860	.09747	.08883	.08662	.15109
	AVG RESP	.93486	.88663	.89868	.95456	.94252	.92607	.92332
4	AVG SP D	.12043	.44269	.41933	.46600	.62451	2.41244	.74757
	AVG RESP	.93111	.79187	.81483	.79986	.68311	.53405	.75927
5	AVG SP D	1.04912	1.04330	1.08129	1.18247	1.43205	2.41670	1.36749
	AVG RESP	.63350	.63088	.62816	.62533	.62240	.61957	.62661
6	AVG SP D	.02827	.20507	.18695	.18560	.18660	.18600	.16342
	AVG RESP	.99998	.99906	.99900	.99883	.99869	.99857	.99902
ALL	AVG SP D	.23230	.35285	.33629	.35807	.44116	.92768	.44149
	AVG RESP	.91268	.87792	.87597	.86942	.82576	.76523	.85450

EQUIRADIAL DESIGN: 8 VERTICES AND 1 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.04516	.06109	.07951	.10005	.12294	.07386
	AVG RESP	.98842	.98215	.97052	.95279	.92810	.89585	.95297
2	AVG SP D	.03457	.04588	.06070	.07743	.09574	.11590	.07170
	AVG RESP	.98840	.98141	.96947	.95197	.92823	.89763	.95288
3	AVG SP D	.06001	.06139	.06673	.07333	.08072	.08904	.07187
	AVG RESP	.96090	.96112	.95856	.95224	.94109	.92399	.94965
4	AVG SP D	.11439	.12977	.17275	.37819	.39855	.34209	.25595
	AVG RESP	.93420	.91796	.87402	.82070	.80609	.78777	.85679
5	AVG SP D	1.04008	1.05028	1.05286	1.05669	1.06168	1.06774	1.05639
	AVG RESP	.63348	.62673	.62390	.61900	.61403	.60899	.62135
6	AVG SP D	.02929	.37438	.31019	.29628	.29115	.28688	.26486
	AVG RESP	.99998	.99794	.99835	.99329	.99818	.99807	.99847
ALL	AVG SP D	.22013	.28448	.28739	.32691	.33798	.33776	.29911
	AVG RESP	.91756	.91155	.89914	.88250	.86928	.85268	.88869

EQUIRADIAL DESIGN: 8 VERTICES AND 2 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.06271	.11855	.22440	.52177	3.43623	.73301
	AVG RESP	.98342	.96444	.90069	.75245	.52906	.34568	.74645
2	AVG SP D	.03457	.06037	.10790	.19173	.38177	2.30475	.51352
	AVG RESP	.98840	.96598	.90456	.77544	.58285	.42577	.77400
3	AVG SP D	.06001	.05690	.08189	.58992	.27095	.41964	.24089
	AVG RESP	.96090	.96568	.95912	.85098	.83758	.82254	.89947
4	AVG SP D	.11439	.06598	.46147	1.19627	1.53202	.80597	.70268
	AVG RESP	.93420	.77629	.76783	.62958	.44537	.48942	.67378
5	AVG SP D	1.04008	1.43584	1.94514	1.25862	4.82601	1.23657	1.94184
	AVG RESP	.63348	.62698	.62436	.61994	.61563	.61141	.62228
6	AVG SP D	.02828	.16300	.26149	1.60347	2.22588	.47563	.79266
	AVG RESP	.99998	.99921	.99359	.60325	.49801	.95730	.87522
ALL	AVG SP D	.22013	.37447	.47941	.84407	1.62640	1.44613	.83177
	AVG RESP	.91756	.88508	.95836	.73911	.58475	.60635	.70520

EQUIRADIAL DESIGN: 8 VERTICES AND 3 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.06213	.11638	.21746	.48085	4.08026	.83425
	AVG RESP	.93842	.96493	.90321	.76109	.54221	.35979	.75327
2	AVG SP D	.03457	.05985	.10591	.16615	.30217	4.96922	.95298
	AVG RESP	.93840	.96446	.90682	.78553	.59495	.43704	.77963
3	AVG SP D	.06001	.05692	.08050	.97657	.32539	.34511	.30742
	AVG RESP	.96090	.96560	.95970	.85477	.83324	.81196	.89770
4	AVG SP D	.11439	.58038	.41929	1.93443	1.49932	.90770	.90925
	AVG RESP	.93420	.77003	.76725	.64513	.44888	.46715	.67311
5	AVG SP D	1.04008	1.41368	1.96743	1.25408	3.04907	1.28901	1.67053
	AVG RESP	.63348	.62087	.62435	.61992	.61559	.61136	.62226
6	AVG SP D	.02828	.16187	.24403	3.90140	4.06907	.53706	1.62362
	AVG RESP	.99098	.99925	.99497	.75527	.29717	.93006	.85078
ALL	AVG SP D	.22013	.38947	.48892	1.41168	1.76531	2.02253	1.04967
	AVG RESP	.91756	.88519	.85938	.73095	.55534	.60453	.75946

EQUIRADIAL DESIGN: 8 VERTICES AND 4 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.06294	.11042	.22723	.53694	2.75478	.62262
	AVG RESP	.93842	.96424	.89967	.74396	.52386	.33700	.74369
2	AVG SP D	.03457	.06058	.10871	.19460	.39003	2.17004	.49412
	AVG RESP	.93840	.96579	.90365	.77557	.57811	.42155	.77181
3	AVG SP D	.06001	.05690	.08247	1.66229	.26372	.73969	.51121
	AVG RESP	.96090	.96571	.95886	.84897	.84029	.82005	.90027
4	AVG SP D	.11439	.84246	.48773	1.19765	1.63087	.77492	.77467
	AVG RESP	.93420	.77639	.76768	.60677	.44195	.49979	.67113
5	AVG SP D	1.04008	1.44502	1.80390	1.26133	6.65246	1.21003	2.23840
	AVG RESP	.63348	.62088	.62436	.61995	.61564	.61143	.62229
6	AVG SP D	.02828	.16348	.26933	2.43275	2.12936	.45492	.91302
	AVG RESP	.99098	.99919	.99291	.85931	.58548	.96222	.89985
ALL	AVG SP D	.22013	.37223	.47859	1.19587	1.93390	1.35533	.92568
	AVG RESP	.91756	.88593	.85786	.74326	.59756	.60977	.76817

EQUIRADIAL DESIGN: 8 VERTICES AND 5 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.05116	.07995	.11841	.17543	.26632	.12083
	AVG RESP	.93842	.97473	.94643	.89468	.81101	.69677	.88567
2	AVG SP D	.03457	.05066	.07380	.10572	.15107	.22061	.10607
	AVG RESP	.93840	.97405	.94640	.89868	.82477	.72652	.89314
3	AVG SP D	.06001	.05983	.06816	.08379	.11053	.15658	.09015
	AVG RESP	.96090	.96553	.96181	.95042	.91786	.84760	.93372
4	AVG SP D	.11439	.68024	.59694	.58223	.74538	9.73006	2.07586
	AVG RESP	.93420	.78759	.78441	.75055	.68134	.55256	.74644
5	AVG SP D	1.04008	1.13573	1.40765	3.31536	2.12602	1.39594	1.73825
	AVG RESP	.63348	.62890	.62414	.61948	.61484	.61021	.62183
6	AVG SP D	.02828	.17309	.16223	.16129	.16281	.16541	.14219
	AVG RESP	.99098	.99945	.99949	.99946	.99940	.99931	.99952
ALL	AVG SP D	.22013	.35645	.39782	.72775	.57854	1.99065	.71222
	AVG RESP	.91756	.88603	.87711	.85221	.80821	.73920	.84705

EQUIRADIAL DESIGN: 8 VERTICES AND 6 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.05136	.07967	.11981	.17840	.27527	.12282
	AVG RESP	.93842	.97454	.94572	.89274	.80685	.69174	.88334
2	AVG SP D	.03457	.05081	.07428	.10680	.15330	.22533	.10752
	AVG RESP	.93840	.97396	.94573	.89696	.82124	.72600	.89113
3	AVG SP D	.06001	.05980	.06825	.08433	.11234	.16445	.09153
	AVG RESP	.96090	.96358	.96185	.95016	.91614	.84249	.93252
4	AVG SP D	.11439	.52982	.48794	.50322	.95187	3.01605	.93401
	AVG RESP	.93420	.78609	.78299	.75316	.68072	.54600	.74730
5	AVG SP D	1.04008	1.13909	1.43163	4.60262	1.95975	1.36914	1.82525
	AVG RESP	.63348	.62081	.62414	.61349	.61485	.61024	.62184
6	AVG SP D	.02828	.17195	.16132	.16030	.16217	.16496	.14153
	AVG RESP	.99098	.99946	.99950	.99946	.99940	.99931	.99952
ALL	AVG SP D	.22013	.33541	.39385	.82958	.58630	.86930	.53711
	AVG RESP	.91756	.88772	.87666	.85200	.80653	.73516	.84594

EQUIRADIAL DESIGN: 8 VERTICES AND 7 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.05012	.07581	.11118	.16031	.23563	.11091
	AVG RESP	.93842	.97578	.95029	.90491	.83283	.73567	.89798
2	AVG SP D	.03457	.04994	.07129	.10007	.13965	.19718	.09876
	AVG RESP	.93840	.97599	.95004	.90761	.84344	.75760	.90376
3	AVG SP D	.06001	.06000	.06770	.08116	.10227	.13498	.08435
	AVG RESP	.96090	.96325	.96153	.95158	.92557	.87212	.93916
4	AVG SP D	.11439	.80658	.50211	.51948	.52830	1.25527	.56735
	AVG RESP	.93420	.80091	.78497	.74798	.70116	.60094	.76269
5	AVG SP D	1.04008	1.11626	1.29975	1.92249	8.82607	1.72993	2.65760
	AVG RESP	.63348	.62080	.62411	.61942	.61474	.61006	.62177
6	AVG SP D	.02828	.18058	.16831	.16697	.16804	.16997	.14702
	AVG RESP	.99098	.99940	.99945	.99941	.99934	.99926	.99947
ALL	AVG SP D	.22013	.32423	.36416	.48356	1.05411	.61963	.61100
	AVG RESP	.91756	.89154	.87840	.85519	.81951	.76264	.85414

EQUIRADIAL DESIGN: 8 VERTICES AND 6 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03643	.04959	.07420	.10755	.15289	.21634	.10617
	AVG RESP	.98842	.97635	.95233	.91017	.84390	.75459	.90426
2	AVG SP D	.03457	.04943	.07002	.09728	.13416	.18026	.09529
	AVG RESP	.98840	.97565	.95196	.91254	.85299	.77378	.90922
3	AVG SP D	.06601	.06010	.06759	.07997	.09674	.12617	.08208
	AVG RESP	.96090	.96309	.96135	.95203	.92869	.88215	.94137
4	AVG SP D	.11439	.60413	.36101	.38737	.50999	1.65272	.60493
	AVG RESP	.93420	.81795	.77745	.75543	.71563	.62068	.77022
5	AVG SP D	1.04909	1.10952	1.25434	1.65049	5.09579	2.31451	2.07892
	AVG RESP	.63348	.62679	.62409	.61939	.61469	.60998	.62174
6	AVG SP D	.02826	.18565	.17251	.17101	.17198	.17376	.15053
	AVG RESP	.99990	.99937	.99941	.99936	.99929	.99920	.99944
ALL	AVG SP D	.22015	.40507	.37326	.41561	1.02726	.77659	.52965
	AVG RESP	.91756	.89553	.87777	.85816	.82586	.77536	.85771

EQUIRADIAL DESIGN: 9 VERTICES AND 1 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.11015	.40337	16.31463	6.24988	1.33903	4.07541
	AVG RESP	.98839	.92915	.58452	.04310	.21531	.27960	.50666
2	AVG SP D	.03462	.12952	3.05690	.08998	.57423	2.65667	1.19069
	AVG RESP	.98839	.92746	.25572	.35474	.43652	.39468	.55995
3	AVG SP D	.06112	.23099	.11172	.13436	.60083	.17345	.21875
	AVG RESP	.96585	.93432	.95979	.94566	.85464	.90315	.92723
4	AVG SP D	.11216	.33161	.86632	1.03206	35.25332	3.20611	6.80026
	AVG RESP	.93562	.72348	.56979	.41560	.44754	.39328	.58122
5	AVG SP D	1.04905	1.27304	1.33026	1.41950	26.77359	1.12379	5.49520
	AVG RESP	.63348	.62628	.62297	.61745	.61160	.60520	.61983
6	AVG SP D	.02829	3.73965	.26229	.22560	.21296	.20640	.77923
	AVG RESP	.99998	.58184	.99348	.99587	.99656	.99669	.92744
ALL	AVG SP D	.21998	.96949	1.00514	3.30275	11.61080	1.45137	3.09326
	AVG RESP	.91862	.78742	.66438	.56207	.59403	.59562	.68706

EQUIRADIAL DESIGN: 9 VERTICES AND 2 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.07645	.18464	.51398	6.17561	2.40066	1.56469
	AVG RESP	.98839	.95309	.83780	.48086	.04458	.08097	.50428
2	AVG SP D	.03462	.09621	.29794	3.33092	.67478	.48729	.81929
	AVG RESP	.98839	.95513	.75713	.09492	.40093	.47393	.61174
3	AVG SP D	.06112	.16500	.25158	.20025	.19365	.25291	.18742
	AVG RESP	.96585	.92320	.90487	.89634	.90083	.86371	.90913
4	AVG SP D	.11216	.35620	.36856	1.04006	6.38217	1.83643	1.68160
	AVG RESP	.93562	.73717	.66863	.51166	.38937	.47325	.61962
5	AVG SP D	1.04904	1.08903	1.84817	1.07836	1.80017	2.10661	1.64423
	AVG RESP	.63348	.62625	.62292	.61744	.61175	.60580	.61994
6	AVG SP D	.02829	4.12256	.36749	.26020	.23374	.22168	.87233
	AVG RESP	.99998	.67384	.98222	.99379	.99554	.99622	.94027
ALL	AVG SP D	.21997	1.13358	.55306	1.07063	2.57669	1.21563	1.12826
	AVG RESP	.91862	.81178	.79560	.59917	.55717	.58265	.71083

EQUIRADIAL DESIGN: 9 VERTICES AND 3 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.07230	.15776	.36119	9.61510	3.68255	2.22059
	AVG RESP	.98839	.95742	.86653	.61051	.24007	.04342	.61772
2	AVG SP D	.03462	.08259	.24065	4.10605	1.05714	.50056	1.00360
	AVG RESP	.98839	.95987	.81815	.18259	.35226	.48012	.63023
3	AVG SP D	.06112	.32779	.15755	.15688	.36009	.25659	.22034
	AVG RESP	.96585	.90679	.92686	.93239	.89988	.87569	.91794
4	AVG SP D	.11216	.83070	.69459	.50509	1.34031	5.05556	1.43973
	AVG RESP	.93562	.73942	.68964	.58168	.40045	.40127	.62468
5	AVG SP D	1.04905	2.81434	1.43154	1.15386	1.23320	1.50603	1.53042
	AVG RESP	.63348	.62624	.62290	.61743	.61177	.60568	.61995
6	AVG SP D	.02828	.70522	.46295	.27389	.24377	.22568	.32463
	AVG RESP	.99998	.84174	.96259	.99240	.99497	.99569	.96460
ALL	AVG SP D	.21997	.73891	.52418	1.09366	2.39160	1.77100	1.12322
	AVG RESP	.91862	.83891	.81444	.65283	.56324	.56708	.72919

EQUIRADIAL DESIGN: 9 VERTICES AND 4 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.04982	.07323	.10603	.15209	.22143	.10620
	AVG RESP	.98839	.97442	.94823	.90341	.83210	.72937	.89602
2	AVG SP D	.03462	.05543	.09473	.17161	.35256	1.90736	.43572
	AVG RESP	.98839	.97759	.94941	.67708	.70256	.41265	.81794
3	AVG SP D	.06112	.18318	.24358	.36533	3.59616	.30425	.79235
	AVG RESP	.96585	.90047	.87353	.87649	.86244	.85607	.88947
4	AVG SP D	.11216	.17773	1.15058	.57663	.55975	.69938	.54607
	AVG RESP	.93562	.85698	.70297	.67525	.63225	.59562	.73280
5	AVG SP D	1.04904	1.51332	1.60745	1.25666	24.93136	1.20636	5.26103
	AVG RESP	.63348	.62820	.62283	.61737	.61181	.60612	.61997
6	AVG SP D	.02829	.21150	.24658	.52407	3.08696	3.58718	1.28076
	AVG RESP	.99993	.99696	.99712	.94815	.89832	.66772	.91837
ALL	AVG SP D	.21997	.36483	.56936	.50017	5.44648	1.62153	1.40369
	AVG RESP	.91862	.88942	.84901	.61639	.75657	.64456	.81243

EQUIRADIAL DESIGN: 9 VERTICES AND 5 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.04956	.07238	.10417	.14649	.21442	.10394
	AVG PESP	.98839	.97465	.94908	.90558	.83677	.73509	.89876
2	AVG SP D	.03462	.05507	.09340	.16751	.33675	2.65555	.58978
	AVG PESP	.98839	.97782	.95046	.88165	.71616	.43245	.82449
3	AVG SP D	.06112	.19645	.26279	1.64533	.65487	.38107	.53360
	AVG PESP	.96585	.89782	.86789	.87193	.85686	.85767	.88637
4	AVG SP D	.11216	.17366	.74213	.51934	.89390	8.03438	1.74593
	AVG PESP	.93562	.86158	.79200	.68084	.63285	.59676	.73528
5	AVG SP D	1.04004	1.49449	1.65271	1.24945	6.57412	1.23538	2.20920
	AVG PESP	.63248	.62620	.62283	.61737	.61181	.60612	.61997
6	AVG SP D	.02828	.21297	.24040	.43090	3.36706	2.92614	1.20096
	AVG PESP	.99998	.99697	.99750	.97580	.84647	.72501	.92362
ALL	AVG SP D	.21097	.76537	.51063	.68612	1.99586	2.60746	1.06390
	AVG PESP	.91862	.88984	.84829	.82220	.75615	.65958	.81475

EQUIRADIAL DESIGN: 9 VERTICES AND 6 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.04777	.06653	.09154	.12473	.17658	.08926
	AVG PESP	.98839	.97641	.95519	.92571	.86842	.79543	.91739
2	AVG SP D	.03462	.05643	.08404	.14051	.24691	.52903	.18106
	AVG PESP	.98839	.97957	.95749	.90776	.79902	.59518	.87045
3	AVG SP D	.06112	.25671	.31616	.41793	.20354	.36001	.27963
	AVG PESP	.96585	.90540	.83712	.84300	.85235	.83667	.87330
4	AVG SP D	.11216	.14988	.23173	.95751	.85069	.58550	.48079
	AVG PESP	.93562	.88626	.78467	.67417	.65369	.60003	.75721
5	AVG SP D	1.04004	1.37497	2.35769	1.24072	1.04527	1.77937	1.57451
	AVG PESP	.63248	.62619	.62282	.61736	.61180	.60614	.61997
6	AVG SP D	.02828	.23148	.22062	.24337	.29977	.45677	.24672
	AVG PESP	.99998	.99692	.99870	.99768	.99494	.98202	.99547
ALL	AVG SP D	.21097	.35221	.54613	.51523	.57182	.64001	.47533
	AVG PESP	.91862	.89613	.85938	.82678	.79671	.73618	.83897

EQUIRADIAL DESIGN: 9 VERTICES AND 7 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.04699	.06412	.08646	.11548	.15429	.08366
	AVG PESP	.98839	.97723	.95789	.92714	.88138	.81613	.92503
2	AVG SP D	.03462	.04924	.08091	.12962	.21696	.40769	.15309
	AVG PESP	.98839	.98037	.96095	.91860	.82864	.66919	.89092
3	AVG SP D	.06112	1.27263	.56116	1.77912	.26973	.74416	.78132
	AVG PESP	.96585	.89623	.85965	.83059	.85533	.83196	.87357
4	AVG SP D	.11216	.14152	.18921	.30595	.56007	.82541	.35539
	AVG PESP	.93562	.89706	.83194	.72032	.64581	.62455	.77585
5	AVG SP D	1.04004	1.32961	3.46415	1.26761	1.41695	3.41166	1.98987
	AVG PESP	.63248	.62619	.62282	.61736	.61180	.60614	.61996
6	AVG SP D	.02828	.24631	.22274	.22923	.25072	.28997	.21121
	AVG PESP	.99998	.99681	.99876	.99817	.99696	.99466	.99789
ALL	AVG SP D	.21097	.51438	.76356	.63303	.47165	.97193	.59576
	AVG PESP	.91862	.89665	.87200	.83523	.80332	.75741	.84720

EQUIRADIAL DESIGN: 9 VERTICES AND 8 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.04625	.06805	.09479	.13076	.18121	.09295
	AVG PESP	.98839	.97593	.95353	.91671	.86021	.78055	.91255
2	AVG SP D	.03462	.05115	.08652	.14738	.26770	.64299	.20506
	AVG PESP	.98839	.97909	.95585	.90114	.77904	.53706	.85686
3	AVG SP D	.06112	.35117	1.99046	.50816	.29873	.31629	.58666
	AVG PESP	.96585	.89165	.85227	.84728	.84203	.83761	.87278
4	AVG SP D	.11216	.15552	.28420	.56557	.47900	.93002	.42110
	AVG PESP	.93562	.88612	.74865	.67576	.64540	.59467	.74707
5	AVG SP D	1.04005	1.40474	2.05765	1.23495	1.90509	1.51694	1.52840
	AVG PESP	.63248	.62619	.62282	.61736	.61180	.60613	.61997
6	AVG SP D	.02828	.22482	.22234	.26274	.38698	1.17228	.38324
	AVG PESP	.99998	.99696	.99856	.99679	.98762	.88113	.97717
ALL	AVG SP D	.21097	.37261	.79497	.46895	.57838	.79262	.53623
	AVG PESP	.91862	.89266	.85528	.82534	.78769	.70653	.83107

EQUIRADIAL DESIGN: 9 VERTICES AND 9 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03462	.04692	.06392	.08604	.11473	.15501	.08321
	AVG PESP	.98839	.97731	.95812	.92768	.88246	.82003	.92566
2	AVG SP D	.03462	.04914	.07967	.12893	.21461	.39970	.15111
	AVG PESP	.98839	.98044	.96122	.91804	.83100	.67501	.89248
3	AVG SP D	.06112	120.90745	.42730	.68155	.27359	.87004	20.53809
	AVG PESP	.96585	.89967	.86129	.83131	.85419	.82955	.87369
4	AVG SP D	.11216	.14695	.18664	.28940	.99206	.79593	.41950
	AVG PESP	.93562	.89775	.83498	.72714	.64499	.62579	.77738
5	AVG SP D	1.04004	1.32597	3.64473	1.27118	1.40585	3.66509	2.09529
	AVG PESP	.63248	.62619	.62292	.61736	.61180	.60614	.61996
6	AVG SP D	.02828	.24796	.22319	.22871	.24871	.28524	.21033
	AVG PESP	.99998	.99690	.99875	.99819	.99702	.99466	.99793
ALL	AVG SP D	.21097	20.45532	.77091	.44755	.54126	1.00264	3.91592
	AVG PESP	.91862	.89703	.87286	.83675	.80356	.75628	.84785

EQUIRADIAL DESIGN: 10 VERTICES AND 1 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.06202	.13381	.31342	3.03758	2.24096	.97137
	AVG RESP	.98839	.96982	.90265	.68954	.43999	.22087	.70188
2	AVG SP D	.03462	.06624	.20218	2.96339	.99861	.39645	.77758
	AVG RESP	.98840	.97678	.89378	.20729	.47950	.68055	.70468
3	AVG SP D	.06043	.27691	.23969	3.23494	.45162	.24109	.75078
	AVG RESP	.96602	.89734	.90330	.68593	.65886	.68667	.89869
4	AVG SP D	.11248	.15623	.38730	.71286	.97853	2.03105	.73016
	AVG RESP	.93540	.86762	.72047	.60412	.57685	.55026	.70912
5	AVG SP D	1.04901	6.75742	1.19376	3.36298	1.08582	1.47421	2.42052
	AVG RESP	.63347	.62940	.62494	.62006	.61472	.60606	.62191
6	AVG SP D	.02829	.33534	.25235	.23248	.22387	.21956	.21532
	AVG RESP	.99698	.99772	.99862	.99677	.99882	.99603	.99879
ALL	AVG SP D	.21990	1.20983	.40152	1.80417	1.12934	1.10097	.97762
	AVG RESP	.91861	.89011	.84063	.66762	.66146	.65004	.77251

EQUIRADIAL DESIGN: 10 VERTICES AND 2 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.06497	.14429	.37993	4.64345	2.32472	1.26533
	AVG RESP	.98839	.96894	.89053	.63392	.42761	.22243	.68932
2	AVG SP D	.03462	.07229	.22885	21.11313	.71222	.36120	3.75372
	AVG RESP	.98840	.97702	.87016	.10306	.52712	.71045	.69703
3	AVG SP D	.06043	.29903	.16409	.36202	.38149	.31306	.25382
	AVG RESP	.96602	.98389	.92369	.91053	.86464	.68005	.90818
4	AVG SP D	.11248	.17517	1.21237	.65902	2.09496	1.08096	.86966
	AVG RESP	.93540	.85005	.69229	.60263	.58684	.55302	.70381
5	AVG SP D	1.04901	89.90016	1.20872	1.83343	1.07898	2.60700	16.27955
	AVG RESP	.63347	.62940	.62492	.61999	.61456	.60059	.62182
6	AVG SP D	.02829	.32825	.31542	.37399	.51578	.84602	.40256
	AVG RESP	.99698	.99606	.99777	.99485	.98199	.88276	.97590
ALL	AVG SP D	.21991	15.13965	.54562	4.11109	1.57115	1.25723	3.80744
	AVG RESP	.91861	.88774	.83323	.64508	.66713	.64437	.76601

EQUIRADIAL DESIGN: 10 VERTICES AND 3 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04817	.07418	.10899	.15449	.21761	.10634
	AVG RESP	.98839	.98271	.96695	.93682	.88574	.80623	.92814
2	AVG SP D	.03462	.04231	.07432	.13129	.23672	.49345	.16912
	AVG RESP	.98840	.99034	.98122	.94352	.85597	.62221	.89778
3	AVG SP D	.06043	.10530	.78697	.25236	2.51430	.31367	.67259
	AVG RESP	.96602	.94991	.83804	.86153	.63665	.83303	.86120
4	AVG SP D	.11248	.10255	.12106	.15867	.18814	.23752	.15207
	AVG RESP	.93540	.92784	.89738	.85353	.80483	.74790	.86148
5	AVG SP D	1.04901	1.23451	3.65452	1.50905	1.20287	1.32601	1.66319
	AVG RESP	.63347	.62944	.62521	.62077	.61613	.61127	.62272
6	AVG SP D	.02829	.60646	.53884	.32319	.27340	.25301	.33680
	AVG RESP	.99698	.95562	.97539	.99028	.99297	.99406	.98471
ALL	AVG SP D	.21990	.35864	.87499	.41219	.70165	.47474	.51669
	AVG RESP	.91861	.90598	.88079	.86891	.83205	.76978	.86267

EQUIRADIAL DESIGN: 10 VERTICES AND 4 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04946	.07855	.11959	.17796	.26950	.12161
	AVG RESP	.98839	.98149	.96247	.92400	.85502	.74647	.90997
2	AVG SP D	.03462	.04446	.09150	.15378	.31548	1.26007	.31508
	AVG RESP	.98940	.98935	.97712	.93064	.77944	.32053	.83091
3	AVG SP D	.06043	.12727	.34015	2.30900	.24041	.51602	.59931
	AVG RESP	.96602	.93528	.85221	.83653	.87938	.82963	.88321
4	AVG SP D	.11248	.10588	.12629	.16137	.20886	.27621	.16552
	AVG RESP	.93541	.92401	.88821	.83751	.77443	.70165	.84357
5	AVG SP D	1.04901	1.29551	7.31561	1.28823	1.22823	2.07747	2.37568
	AVG RESP	.63347	.62944	.62518	.62069	.61596	.61099	.62262
6	AVG SP D	.02828	1.53465	.40428	.28234	.25046	.23628	.45605
	AVG RESP	.99693	.70928	.98609	.99283	.99442	.99511	.94629
ALL	AVG SP D	.21990	.52620	1.39106	.71905	.48357	.77346	.67221
	AVG RESP	.91861	.86147	.88188	.85703	.81644	.70113	.83943

EQUIRADIAL DESIGN: 10 VERTICES AND 5 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04671	.07600	.11337	.16399	.23777	.11241
	AVG RESP	.98839	.98219	.96508	.93157	.87334	.78417	.92079
2	AVG SP D	.03462	.04523	.07739	.14030	.26588	.64625	.20076
	AVG RESP	.98840	.98992	.97955	.94152	.82733	.52691	.87560
3	AVG SP D	.06043	.11505	.49344	.30539	.29240	.48259	.29127
	AVG RESP	.96602	.94565	.85060	.86651	.85425	.82447	.88458
4	AVG SP D	.11248	.10594	.12322	.15505	.19617	.25521	.15735
	AVG RESP	.93541	.92622	.89353	.84803	.79233	.72699	.85408
5	AVG SP D	1.04900	1.25915	8.59510	1.38509	1.20074	1.49409	2.49553
	AVG RESP	.63347	.62944	.62519	.62074	.61606	.61115	.62267
6	AVG SP D	.02828	.92091	.46623	.30133	.26218	.24520	.35402
	AVG RESP	.99698	.91103	.98137	.99158	.99369	.99453	.97870
ALL	AVG SP D	.21990	.39617	1.63688	.40017	.39690	.55932	.60189
	AVG RESP	.91861	.89741	.88255	.86606	.82617	.74509	.85607

EQUIRADIAL DESIGN: 10 VERTICES AND 6 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04658	.07555	.11229	.16162	.23263	.11088
	AVG RESP	.98839	.98232	.96554	.93287	.87645	.79020	.92263
2	AVG SP D	.03462	.04301	.07657	.13002	.25834	.59968	.19174
	AVG RESP	.98840	.99002	.97997	.94330	.83478	.55530	.88166
3	AVG SP D	.06043	.11110	.49105	.28511	.31877	.40446	.27849
	AVG RESP	.96602	.94087	.85311	.66145	.84875	.83033	.88442
4	AVG SP D	.11240	.10360	.12269	.15396	.19413	.24923	.15601
	AVG RESP	.93541	.92061	.89447	.84998	.79542	.73069	.85591
5	AVG SP D	1.04001	1.25590	6.32186	1.40982	1.19944	1.44296	2.11268
	AVG RESP	.63347	.62944	.62529	.62074	.61607	.61129	.62268
6	AVG SP D	.02828	.75667	.48108	.30546	.26467	.24703	.34721
	AVG RESP	.99898	.92695	.97019	.99130	.99353	.99446	.98092
ALL	AVG SP D	.21990	.78599	1.26147	.40078	.39950	.52937	.53283
	AVG RESP	.91861	.90022	.88308	.86659	.82750	.75223	.85804

EQUIRADIAL DESIGN: 10 VERTICES AND 7 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.05038	.08179	.12773	.19725	.31023	.13500
	AVG RESP	.98839	.98063	.95913	.91368	.82984	.69919	.89518
2	AVG SP D	.03462	.04599	.38697	.17309	.39948	42.17364	7.15266
	AVG RESP	.98840	.98663	.97385	.91463	.70186	.24026	.80227
3	AVG SP D	.06043	.16299	.80914	.43752	.23748	.54364	.37556
	AVG RESP	.96602	.90164	.37209	.85028	.87446	.84193	.80434
4	AVG SP D	.11240	.10637	.13054	.16969	.22670	.31718	.17753
	AVG RESP	.93541	.92126	.88143	.82373	.75048	.66773	.83001
5	AVG SP D	1.04001	1.74573	2.96054	1.22041	1.31045	145.43602	25.55916
	AVG RESP	.63347	.62943	.62515	.62063	.61584	.61060	.62255
6	AVG SP D	.02828	22.36124	.35629	.26531	.23954	.22704	3.91308
	AVG RESP	.99898	.59477	.98947	.99390	.99508	.99561	.92814
ALL	AVG SP D	.21990	4.01245	.72088	.39999	.43615	31.50362	6.21550
	AVG RESP	.91861	.83606	.88352	.85284	.79459	.67005	.82708

EQUIRADIAL DESIGN: 10 VERTICES AND 8 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04937	.07825	.11885	.17629	.26353	.12048
	AVG RESP	.98839	.98157	.96278	.92490	.85724	.75279	.91128
2	AVG SP D	.03462	.04432	.08100	.15215	.30908	1.06002	.28120
	AVG RESP	.98840	.98941	.97741	.93198	.78558	.35005	.83722
3	AVG SP D	.06043	.12524	.36925	2.46085	.24299	.58308	.64224
	AVG RESP	.96602	.93091	.85296	.83696	.87798	.82024	.88285
4	AVG SP D	.11240	.10566	.12593	.16062	.20732	.27303	.16450
	AVG RESP	.93541	.92427	.88883	.83375	.77057	.70306	.84481
5	AVG SP D	1.04001	1.29112	9.02826	1.29069	1.22326	1.96395	2.64205
	AVG RESP	.63347	.62944	.62518	.62069	.61597	.61101	.62263
6	AVG SP D	.02828	1.39396	.41007	.28425	.25166	.23720	.43424
	AVG RESP	.99898	.74555	.98567	.99270	.99435	.99306	.95222
ALL	AVG SP D	.21990	.80161	1.68213	.74057	.40177	.73274	.71412
	AVG RESP	.91861	.86786	.88214	.85706	.81795	.70078	.84183

EQUIRADIAL DESIGN: 10 VERTICES AND 9 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04773	.07271	.10541	.14086	.20212	.10157
	AVG RESP	.98839	.98317	.96853	.94112	.89566	.82739	.93404
2	AVG SP D	.03462	.04153	.07183	.12415	.21546	.41213	.14995
	AVG RESP	.98840	.99070	.98259	.95392	.87680	.68099	.91323
3	AVG SP D	.06043	.10087	.38894	.24382	.53902	.29006	.27063
	AVG RESP	.96602	.95236	.86004	.87039	.83281	.83076	.88673
4	AVG SP D	.11240	.10138	.11926	.14715	.18172	.22334	.14789
	AVG RESP	.93541	.92924	.90066	.86182	.81518	.76331	.86760
5	AVG SP D	1.04001	1.21465	2.60815	1.69031	1.22246	1.25216	1.50621
	AVG RESP	.63347	.62944	.62522	.62061	.61620	.61139	.62275
6	AVG SP D	.02828	.49154	.63915	.34151	.28563	.26204	.34146
	AVG RESP	.99898	.97281	.96637	.98376	.99217	.99349	.98559
ALL	AVG SP D	.21990	.33295	.65001	.44214	.43186	.44004	.41962
	AVG RESP	.91861	.90962	.89390	.87280	.83813	.78089	.86833

EQUIRADIAL DESIGN: 10 VERTICES AND 10 CENTER POINTS

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03460	.04705	.07027	.09940	.13435	.17765	.09392
	AVG RESP	.98839	.98401	.97132	.94847	.91212	.85008	.94387
2	AVG SP D	.03462	.04008	.06795	.11235	.18431	.31151	.12505
	AVG RESP	.98840	.99135	.98489	.96246	.90739	.78170	.93603
3	AVG SP D	.06043	.09386	.27810	.30328	.96234	.34049	.34075
	AVG RESP	.96602	.95520	.83802	.84078	.81667	.82275	.87424
4	AVG SP D	.11240	.09929	.11612	.14138	.17080	.20357	.14094
	AVG RESP	.93541	.93181	.90662	.87305	.83333	.78969	.87632
5	AVG SP D	1.04001	1.18123	1.84481	2.63339	1.32554	1.20277	1.54029
	AVG RESP	.63347	.62945	.62525	.62088	.61633	.61160	.62283
6	AVG SP D	.02828	.35984	1.23127	.40266	.31832	.28017	.43776
	AVG RESP	.99898	.98699	.98547	.98408	.98992	.99195	.97307
ALL	AVG SP D	.21990	.30356	.60134	.61024	.51594	.42173	.44045
	AVG RESP	.91861	.91514	.86859	.87262	.84596	.80943	.87139

UNIFORM PRECISION COMBINATION DESIGN: 5 RADIAL AND 5 INNER VERTICES R2/R1= .374

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07297	.06044	.05556	.05679	.06180	.06941	.06300
	AVG PESP	.96114	.98110	.98897	.99002	.98743	.98251	.98185
2	AVG SP D	.07003	.06078	.06508	.07630	.09201	.10721	.07865
	AVG PESP	.96430	.97330	.97169	.96527	.95634	.94547	.96272
3	AVG SP D	.11380	.11437	.24983	.16015	.11974	.12215	.14768
	AVG PESP	.94794	.94780	.89731	.93830	.94598	.94043	.93729
4	AVG SP D	.69773	.71016	.25972	.23751	.22422	.22079	.32602
	AVG PESP	.74987	.79799	.83844	.87296	.89044	.89670	.84107
5	AVG SP D	.40288	.42775	.45741	.49355	.53902	.59608	.48658
	AVG PESP	.69942	.68779	.67551	.66261	.65008	.63765	.66891
6	AVG SP D	.03126	.12896	.16015	.21949	.38765	5.72097	1.10908
	AVG PESP	.99996	.99965	.99902	.99638	.97445	.70540	.94548
ALL	AVG SP D	.23162	.18474	.20796	.20838	.23741	1.14090	.36850
	AVG PESP	.88712	.89794	.89512	.90429	.90079	.85266	.88955

UNIFORM PRECISION COMBINATION DESIGN: 5 RADIAL AND 6 INNER VERTICES R2/R1= .413

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07660	.06696	.06707	.07653	.09403	.12607	.08379
	AVG PESP	.95805	.97684	.98342	.98093	.96980	.94762	.96944
2	AVG SP D	.07319	.06980	.08251	.10196	.12555	.15465	.10123
	AVG PESP	.96122	.96570	.95418	.93644	.91139	.87942	.93439
3	AVG SP D	.18667	.12290	.11692	.12757	.17347	.67279	.20670
	AVG PESP	.93640	.94044	.94534	.93646	.90182	.89748	.92683
4	AVG SP D	1.00205	.41700	.32061	.58149	.26206	.29943	.48044
	AVG PESP	.73015	.79030	.82704	.85560	.87221	.88207	.82786
5	AVG SP D	.41780	.44327	.47369	.51092	.55800	.62046	.50402
	AVG PESP	.69331	.68185	.67019	.65868	.64783	.63793	.66496
6	AVG SP D	.03119	.15616	.29394	1.16352	4.14760	.69226	1.08074
	AVG PESP	.99998	.99926	.99277	.91674	.69561	.86613	.91175
ALL	AVG SP D	.29792	.21266	.22579	.42690	.89346	.46619	.41949
	AVG PESP	.88186	.89206	.89549	.88084	.83311	.85167	.87254

UNIFORM PRECISION COMBINATION DESIGN: 5 RADIAL AND 7 INNER VERTICES R2/R1= .438

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07935	.07369	.07712	.09043	.11560	.15669	.09885
	AVG PESP	.95512	.97150	.97700	.97144	.95158	.90971	.95606
2	AVG SP D	.07627	.07766	.09579	.12298	.15542	.19321	.12056
	AVG PESP	.95826	.95677	.94322	.91887	.88405	.84606	.91697
3	AVG SP D	.16628	.17913	.50570	.14067	.12851	.13474	.20917
	AVG PESP	.90928	.91164	.91069	.90741	.91829	.90615	.91091
4	AVG SP D	.93002	.35615	.45826	.31963	.36750	.28595	.45475
	AVG PESP	.72841	.76672	.80469	.83554	.85271	.86121	.80821
5	AVG SP D	.43134	.45220	.47638	.50488	.53913	.58143	.49756
	AVG PESP	.68907	.67917	.67032	.66170	.65345	.64502	.66637
6	AVG SP D	.03118	.16046	.33304	1.58046	3.36217	.63653	1.01764
	AVG PESP	.99998	.99912	.99145	.87069	.53894	.89699	.88319
ALL	AVG SP D	.28724	.21688	.32438	.45984	.77806	.33213	.39976
	AVG PESP	.87319	.88082	.88290	.86094	.79984	.84404	.85695

UNIFORM PRECISION COMBINATION DESIGN: 5 RADIAL AND 8 INNER VERTICES R2/R1= .455

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.08161	.06540	.06040	.06727	.09048	.12161	.08116
	AVG PESP	.95269	.97727	.98646	.98484	.97526	.95945	.97266
2	AVG SP D	.07883	.07532	.08963	.10783	.12688	.14606	.10386
	AVG PESP	.95576	.96027	.95428	.94272	.92769	.91623	.94183
3	AVG SP D	.11919	.14389	2.99496	.12067	.14036	.27145	.63279
	AVG PESP	.93884	.92061	.90438	.92062	.90473	.86964	.90984
4	AVG SP D	1.12030	.34707	.30651	.34713	.62192	.90169	.60747
	AVG PESP	.71823	.76204	.81692	.81391	.77082	.73731	.76987
5	AVG SP D	.44577	.47921	.52082	.57468	.64859	.76641	.57158
	AVG PESP	.68325	.67147	.66002	.64912	.63624	.62419	.65438
6	AVG SP D	.03116	.14426	.22530	.32723	.44776	.58714	.29381
	AVG PESP	.99998	.99905	.99654	.99199	.98501	.97519	.99129
ALL	AVG SP D	.31281	.20686	.69960	.25858	.34600	.46469	.38178
	AVG PESP	.87479	.88179	.88643	.86386	.86696	.84604	.87331

UNIFORM PRECISION COMBINATION DESIGN: 5 RADIAL AND 9 INNER VERTICES R2/R1= .466

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.08357	.06769	.06058	.06252	.07439	.09442	.07386
	AVG PESP	.95959	.97512	.98428	.98723	.98411	.97608	.97595
2	AVG SP D	.08101	.07262	.08145	.09667	.11328	.13061	.09594
	AVG PESP	.95360	.96182	.96175	.95650	.94780	.93603	.95302
3	AVG SP D	.12613	.11630	.12070	.17335	.15138	.30609	.16499
	AVG PESP	.93305	.93575	.93229	.89255	.90645	.88047	.91443
4	AVG SP D	1.70680	.44161	.95811	.63989	.94712	5.27626	1.60180
	AVG PESP	.70938	.74598	.74969	.67166	.66764	.67627	.70330
5	AVG SP D	.46146	.48693	.51695	.55315	.59803	.65392	.54541
	AVG PESP	.67879	.67696	.66331	.65593	.64873	.64131	.65984
6	AVG SP D	.03114	.13147	.18835	.24647	.30447	.36129	.21053
	AVG PESP	.99998	.99924	.99762	.99524	.99226	.98608	.99554
ALL	AVG SP D	.41366	.21940	.32102	.29534	.36478	1.13610	.43676
	AVG PESP	.87073	.88081	.88149	.85989	.85784	.85152	.86701

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND 10 INNER VERTICES R2/R1= .475

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06029	.07060	.06672	.07436	.08939	.10726	.08227
	AVG RESP	.98875	.97078	.98051	.98210	.97776	.96002	.97142
2	AVG SP D	.08294	.07505	.08016	.09351	.11611	.13901	.09613
	AVG RESP	.95171	.96240	.96262	.95536	.94394	.92760	.95072
3	AVG SP D	.13787	.12493	.11982	.11968	.12142	.12762	.12502
	AVG RESP	.91146	.92518	.93022	.92993	.92595	.91619	.92347
4	AVG SP D	8.92336	.53148	.60000	.99247	1.66055	2.80560	2.61861
	AVG RESP	.69897	.73594	.65896	.65032	.66095	.66741	.67871
5	AVG SP D	.47860	.50363	.57288	.56807	.61162	.66762	.56044
	AVG RESP	.67466	.66848	.66247	.65669	.65114	.64569	.65984
6	AVG SP D	.03112	.13613	.19200	.26994	.36490	.47677	.24448
	AVG RESP	.99998	.99929	.99746	.99397	.98827	.97904	.99310
ALL	AVG SP D	1.62323	.23930	.26526	.35524	.52733	.72658	.62149
	AVG RESP	.86826	.87791	.86537	.86143	.85800	.85129	.86268

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND 5 INNER VERTICES R2/R1= .321

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03818	.04596	.07267	.10874	.15548	.21957	.10677
	AVG RESP	.98451	.98660	.97917	.95673	.91571	.84478	.94442
2	AVG SP D	.04269	.05212	.07078	.09067	.11103	.13253	.08330
	AVG RESP	.98236	.97739	.96637	.95026	.92671	.90095	.95101
3	AVG SP D	.17659	.12530	.09960	.08657	.08527	.08616	.10984
	AVG RESP	.96286	.97928	.98349	.98390	.98232	.97911	.97849
4	AVG SP D	.11294	.17092	.52093	.69996	.67657	2.64093	.83838
	AVG RESP	.92347	.89080	.81311	.82016	.80499	.68740	.82332
5	AVG SP D	1.22810	.83713	1.08032	2.86851	1.00394	1.17695	1.38216
	AVG RESP	.65776	.65975	.66175	.66376	.66578	.66760	.66277
6	AVG SP D	.02852	2.10527	.39670	.28954	.25923	.24344	.50745
	AVG RESP	.99998	.75683	.98839	.99472	.99588	.99655	.95569
ALL	AVG SP D	.27075	.58612	.37350	.72400	.38192	.75159	.51465
	AVG RESP	.91850	.87544	.89855	.89492	.88223	.84006	.88595

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND 6 INNER VERTICES R2/R1= .374

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04354	.05477	.08863	.13853	.21133	.32695	.14429
	AVG RESP	.98184	.98141	.96712	.93007	.85338	.72508	.90648
2	AVG SP D	.04504	.05464	.07444	.09751	.12318	.15251	.09119
	AVG RESP	.97970	.97287	.95855	.93655	.90580	.86510	.93643
3	AVG SP D	.19019	.14086	.11299	.09857	.09828	.10104	.12362
	AVG RESP	.95645	.97579	.98186	.98244	.97962	.97505	.97500
4	AVG SP D	.11277	.19567	.53610	.62192	4.93914	11.04558	2.90820
	AVG RESP	.91801	.85954	.79134	.80190	.69981	.53906	.76838
5	AVG SP D	.96798	.89960	1.03743	4.81633	1.11892	.92298	1.62754
	AVG RESP	.67084	.67526	.67569	.67814	.68062	.68541	.67694
6	AVG SP D	.02744	1.58561	.32143	.26760	.24923	.24605	.44876
	AVG RESP	.99998	.75083	.99466	.99641	.99685	.99704	.95596
ALL	AVG SP D	.23135	.48652	.36184	1.00694	1.12334	2.13162	.89060
	AVG RESP	.91780	.86695	.89487	.88759	.85266	.79731	.86986

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND 7 INNER VERTICES R2/R1= .408

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04825	.05450	.08374	.12024	.16395	.21755	.11471
	AVG RESP	.97040	.98245	.97253	.94964	.91196	.85707	.94217
2	AVG SP D	.04721	.05412	.07138	.08989	.10816	.12661	.08290
	AVG RESP	.97732	.97599	.96397	.94919	.93014	.90693	.95025
3	AVG SP D	.21275	.13498	.10069	.08753	.08703	.08691	.11865
	AVG RESP	.93777	.97526	.98249	.98067	.97454	.96452	.96924
4	AVG SP D	.11344	.13261	.28516	.69605	.77033	.92209	.48071
	AVG RESP	.91274	.92912	.83642	.73741	.67717	.58406	.77959
5	AVG SP D	.84152	.97068	2.65283	.91715	1.15978	1.19765	1.29750
	AVG RESP	.68172	.68508	.68456	.68614	.68779	.68951	.68546
6	AVG SP D	.02538	2.10719	24.51565	.92068	.67607	.58746	4.82224
	AVG RESP	.99998	.77557	.44382	.90808	.96454	.97611	.84468
ALL	AVG SP D	.22192	.59168	4.61824	.47302	.49456	.52528	1.15378
	AVG RESP	.91682	.88658	.81396	.86355	.85769	.82960	.86190

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND 8 INNER VERTICES R2/R1= .431

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05335	.05593	.07608	.10596	.14193	.18452	.10247
	AVG RESP	.97717	.98087	.97496	.95951	.93379	.89606	.95383
2	AVG SP D	.04851	.05528	.06651	.07949	.09491	.11656	.07521
	AVG RESP	.97617	.97554	.96665	.95582	.94154	.92599	.95612
3	AVG SP D	[illegible]	.16191	.11826	.09585	.08728	.08670	.13511
	AVG RESP	[illegible]	.95952	.97532	.97755	.97367	.96669	.95746
4	AVG SP D	.11653	.12635	.20090	.52147	1.22839	1.20265	.58570
	AVG RESP	.90392	.92647	.89025	.77062	.67504	.59651	.79547
5	AVG SP D	.84110	.96668	23.60474	.98172	.68548	1.38998	4.77628
	AVG RESP	.69120	.69171	.69233	.69304	.69383	.69470	.69280
6	AVG SP D	[illegible]	.50973	5.42265	7.55339	1.44354	1.02767	2.67926
	AVG RESP	[illegible]	.69286	.54770	.41040	.72186	.69625	.70052
ALL	AVG SP D	[illegible]	.72682	4.01650	1.55632	.64692	.66764	1.30939
	AVG RESP	[illegible]	.92083	.84122	.79449	.82329	.82698	.85237

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND [illegible] INNER VERTICES R2/R1= .447

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05592	.05529	.07153	.10112	.13744	.18163	.10032
	AVG PESP	.97513	.98085	.97716	.96634	.94029	.90477	.95702
2	AVG SP D	.05180	.05160	.06223	.07694	.09244	.10041	.07590
	AVG PESP	.97721	.97572	.96852	.95907	.94598	.92349	.95833
3	AVG SP D	.33953	.19044	.12813	.09777	.08375	.08100	.16161
	AVG PESP	.77075	.93765	.96952	.97570	.97305	.96558	.93204
4	AVG SP D	.11580	.12650	.20369	.40840	4.65343	3.35950	1.51122
	AVG PESP	.99552	.92293	.88081	.76830	.68615	.60690	.79510
5	AVG SP D	.62249	1.06437	2.04403	.68895	.87462	1.71713	1.23526
	AVG PESP	.69960	.69973	.70094	.70049	.70107	.70178	.70045
6	AVG SP D	.02234	.33063	1.15379	7.96290	7.77254	3.23992	3.41469
	AVG PESP	.99998	.99705	.96827	.46455	.10645	.34963	.65099
ALL	AVG SP D	.24881	.30514	.61057	1.58318	2.50237	1.44793	1.08283
	AVG PESP	.87703	.91666	.91672	.60867	.72550	.74536	.83232

UNIFORM PRECISION COMBINATION DESIGN: 6 RADIAL AND 10 INNER VERTICES R2/R1= .459

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05609	.06050	.07325	.10259	.14554	.20551	.10733
	AVG PESP	.97325	.97992	.97153	.95370	.92604	.87249	.94765
2	AVG SP D	.05605	.05513	.06595	.08349	.10217	.12158	.08006
	AVG PESP	.97141	.97218	.96691	.95438	.93815	.91755	.95323
3	AVG SP D	.62171	.23630	.13615	.09606	.07833	.07546	.24085
	AVG PESP	.67725	.89094	.96219	.97365	.97196	.96449	.90691
4	AVG SP D	.11706	.13564	.25746	1.47376	1.49168	8.68592	2.02692
	AVG PESP	.69947	.91399	.82298	.71226	.62687	.55212	.75462
5	AVG SP D	.61780	1.75715	1.13973	.62053	.95667	2.73960	1.30525
	AVG PESP	.70713	.70710	.70727	.70764	.70820	.70695	.70772
6	AVG SP D	.02834	.29502	3.30105	5.68606	1.68282	.93914	1.92207
	AVG PESP	.99998	.99732	.37974	.55208	.51007	.64235	.71359
ALL	AVG SP D	.31634	.35671	.82893	1.27718	.77620	2.12712	.94708
	AVG PESP	.87159	.91024	.80227	.80979	.78022	.80962	.83062

UNIFORM PRECISION COMBINATION DESIGN: 7 RADIAL AND 5 INNER VERTICES R2/R1= .256

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03699	.06259	.11595	.21045	.42203	2.91290	.62682
	AVG PESP	.98552	.97695	.92609	.81340	.60923	.39764	.78384
2	AVG SP D	.03666	.05558	.08231	.11628	.16961	.25178	.11904
	AVG PESP	.98555	.96622	.92983	.86818	.77561	.66048	.86431
3	AVG SP D	.18185	.78530	.24694	.16205	.10220	.09409	.26174
	AVG PESP	.99293	.87777	.87108	.89041	.91845	.88536	.89100
4	AVG SP D	.11576	.62540	6.08451	.74524	4.57386	.84770	2.16508
	AVG PESP	.92676	.76548	.77888	.63089	.43458	.49177	.67140
5	AVG SP D	1.02257	1.02277	1.02304	1.02336	1.02372	1.02414	1.02327
	AVG PESP	.64910	.64734	.64556	.64375	.64191	.64004	.64461
6	AVG SP D	.02811	.17280	.16776	.17161	.17636	.18667	.14958
	AVG PESP	.99998	.99942	.99932	.99914	.99896	.99879	.99927
ALL	AVG SP D	.23699	.45341	1.28675	.40516	1.07796	.88524	.72425
	AVG PESP	.90831	.87120	.85846	.80763	.72979	.67905	.80907

UNIFORM PRECISION COMBINATION DESIGN: 7 RADIAL AND 6 INNER VERTICES R2/R1= .330

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03040	.06018	.09958	.15442	.23336	.36659	.15788
	AVG PESP	.99305	.97540	.94448	.88557	.78919	.67521	.87482
2	AVG SP D	.03915	.05468	.07696	.10332	.13486	.17415	.09718
	AVG PESP	.98306	.96617	.94251	.90392	.85141	.78760	.90615
3	AVG SP D	.34173	.14781	.08763	.07600	.07855	.08598	.13628
	AVG PESP	.85422	.92143	.96669	.95161	.92455	.88001	.91785
4	AVG SP D	.11369	.91101	.50660	1.44803	2.14328	28.17974	5.55039
	AVG PESP	.92217	.73685	.76663	.71366	.51380	.36143	.66942
5	AVG SP D	1.13769	1.61619	32.23345	1.57368	1.14914	1.03076	6.45815
	AVG PESP	.66208	.65949	.65680	.65401	.65111	.64811	.65527
6	AVG SP D	.02902	.25799	.23023	.22570	.22493	.22515	.19865
	AVG PESP	.99998	.99959	.99865	.99851	.99836	.99825	.99873
ALL	AVG SP D	.28328	.50629	5.53907	.59719	.60068	5.01663	2.09976
	AVG PESP	.90276	.87066	.87929	.85121	.78807	.72624	.83704

UNIFORM PRECISION COMBINATION DESIGN: 7 RADIAL AND 7 INNER VERTICES R2/R1= .374

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04214	.06100	.09629	.14615	.21750	.32696	.14867
	AVG PESP	.93979	.97067	.94552	.88987	.80206	.69213	.87984
2	AVG SP D	.04195	.05486	.07462	.09873	.12794	.16424	.09372
	AVG PESP	.98580	.96590	.94121	.90472	.85548	.79559	.90728
3	AVG SP D	.84685	.17758	.10779	.09277	.08990	.09247	.20118
	AVG PESP	.81070	.89129	.95269	.94420	.91922	.88492	.90200
4	AVG SP D	.11306	.33593	.56229	1.19064	7.78997	5.71923	2.61852
	AVG PESP	.91756	.75534	.74589	.71321	.52283	.37121	.67067
5	AVG SP D	1.52233	2.05743	4.20169	1.65711	1.24971	1.69669	2.11083
	AVG PESP	.67309	.66986	.66655	.66316	.65968	.65612	.66475
6	AVG SP D	.02797	.25539	.22515	.21960	.21842	.21632	.19418
	AVG PESP	.99099	.99868	.99879	.99867	.99855	.99843	.99885
ALL	AVG SP D	.39667	.64036	.87797	.56750	1.61557	1.27662	.89452
	AVG PESP	.80832	.87496	.87478	.85231	.79297	.73567	.83723

UNIFORM PRECISION COMBINATION DESIGN: 7 RADIAL AND 8 INNER VERTICES R2/R1= .404

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04405	.06106	.09251	.13350	.20413	.30595	.14087
	AVG RESP	.97873	.97063	.94760	.90120	.82276	.71608	.88983
2	AVG SP D	.04401	.05517	.07259	.09448	.12026	.15124	.08980
	AVG RESP	.97874	.96524	.94346	.91194	.86986	.81021	.91457
3	AVG SP D	.70064	.17780	.11668	.10123	.09676	.09706	.21503
	AVG RESP	.82218	.88570	.94259	.94035	.92211	.89521	.90134
4	AVG SP D	.11314	.27409	.79427	1.13734	1.00107	2.29630	.93604
	AVG RESP	.91327	.78241	.73674	.72148	.54245	.39006	.68120
5	AVG SP D	3.05316	2.26019	1.27198	1.04623	.90467	.94590	1.69036
	AVG RESP	.69272	.67938	.67596	.67245	.66687	.66521	.67410
6	AVG SP D	.02794	.30453	.25022	.23790	.23347	.23169	.21429
	AVG RESP	.99999	.99793	.99828	.99815	.99799	.99703	.99836
ALL	AVG SP D	.76416	.52214	.43304	.45928	.43673	.67162	.54773
	AVG RESP	.89594	.88022	.87409	.85700	.80400	.74757	.84324

UNIFORM PRECISION COMBINATION DESIGN: 7 RADIAL AND 9 INNER VERTICES R2/R1= .425

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04796	.06535	.09582	.14658	.22456	.35012	.15572
	AVG RESP	.97489	.96929	.94541	.89417	.80291	.68057	.87816
2	AVG SP D	.04411	.05702	.07566	.09373	.12036	.16014	.09434
	AVG RESP	.97683	.96292	.94025	.90718	.86252	.80094	.90944
3	AVG SP D	1.76160	.18023	.12200	.10652	.10174	.10158	.39561
	AVG RESP	.78909	.87950	.93246	.93249	.91740	.89428	.89070
4	AVG SP D	.11371	.31968	.90879	.65438	2.62486	4.67004	1.61671
	AVG RESP	.90929	.74482	.73050	.68211	.53390	.40956	.66836
5	AVG SP D	3.20604	1.22275	.97400	.90359	.90911	.99323	1.36745
	AVG RESP	.69126	.68798	.68460	.68114	.67761	.67400	.68277
6	AVG SP D	.02793	.30060	.23957	.22642	.22192	.22022	.20611
	AVG RESP	.99999	.99755	.99795	.99777	.99755	.99736	.99803
ALL	AVG SP D	.86656	.35727	.40264	.35604	.73476	1.11669	.63933
	AVG RESP	.89539	.87368	.87186	.84914	.79865	.74375	.83791

UNIFORM PRECISION COMBINATION DESIGN: 7 RADIAL AND 10 INNER VERTICES R2/R1= .440

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05078	.06927	.10692	.17327	.29580	.59498	.21517
	AVG RESP	.97508	.96509	.93465	.86294	.72381	.53310	.83245
2	AVG SP D	.05103	.06100	.08112	.10764	.14219	.18768	.10514
	AVG RESP	.97508	.95638	.93088	.88926	.83044	.75423	.88971
3	AVG SP D	2.13651	.23657	.15423	.13074	.12318	.12144	.46311
	AVG RESP	.75081	.82478	.89216	.90221	.89144	.87036	.85683
4	AVG SP D	.11457	.69173	1.25370	.74854	2.94627	.91302	1.11141
	AVG RESP	.90561	.68082	.71453	.63215	.49004	.53090	.66101
5	AVG SP D	1.55393	1.08303	.93683	.88230	.87548	.91124	1.04130
	AVG RESP	.69394	.69597	.69272	.68951	.68623	.68268	.69103
6	AVG SP D	.02792	.23152	.19500	.18849	.18745	.18001	.16973
	AVG RESP	.99999	.99658	.99860	.99836	.99811	.99769	.99859
ALL	AVG SP D	.65562	.39585	.45463	.37186	.76173	.48616	.52098
	AVG RESP	.88675	.85492	.86059	.82907	.77001	.72926	.82160

UNIFORM PRECISION COMBINATION DESIGN: 8 RADIAL AND 5 INNER VERTICES R2/R1= .170

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03524	.05414	.08521	.12917	.19405	.30158	.13320
	AVG RESP	.98733	.97198	.93972	.88079	.78873	.67352	.87368
2	AVG SP D	.03536	.05293	.07807	.11270	.16219	.23915	.11340
	AVG RESP	.98731	.97123	.94009	.88696	.80755	.70054	.88361
3	AVG SP D	.05567	.05612	.06580	.08335	.11183	.15958	.08878
	AVG RESP	.96067	.97154	.96754	.95176	.91313	.83827	.93532
4	AVG SP D	.11227	1.14179	.45981	.48830	1.25523	2.97140	1.07147
	AVG RESP	.93272	.77366	.77095	.74146	.63873	.49238	.72502
5	AVG SP D	1.02081	1.05394	1.18675	1.64460	21.46475	1.64371	4.66943
	AVG RESP	.63093	.63466	.62939	.62411	.61883	.61334	.62674
6	AVG SP D	.02021	.18195	.17056	.16958	.17072	.17313	.14899
	AVG RESP	.99998	.99940	.99945	.99942	.99937	.99929	.99948
ALL	AVG SP D	.21459	.42348	.34103	.43792	3.89313	.91511	1.03754
	AVG RESP	.91049	.88708	.87452	.84742	.79439	.72096	.84064

UNIFORM PRECISION COMBINATION DESIGN: 8 RADIAL AND 6 INNER VERTICES R2/R1= .280

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03724	.05760	.08898	.13376	.20128	.31636	.13924
	AVG RESP	.98402	.96748	.93207	.86838	.77209	.65227	.86297
2	AVG SP D	.03734	.05722	.08587	.12551	.18310	.27581	.12747
	AVG RESP	[illegible]	.96681	.93184	.87237	.78497	.67936	.87006
3	AVG SP D	.06691	.08372	.06276	.08879	.13398	.21152	.09883
	AVG RESP	[illegible]	.98309	.97654	.95526	.90516	.81662	.93551
4	AVG SP D	.10059	.56957	.49327	.48056	.85264	4.66432	1.19502
	AVG RESP	.92667	.78486	.75061	.72262	.61053	.46390	.71120
5	AVG SP D	1.04117	.98902	1.03502	1.22859	2.54645	2.10490	1.45752
	AVG RESP	.65264	.64695	.64105	.63525	.62944	.62362	.63814
6	AVG SP D	.02410	.17941	.16680	.16376	.16303	.16336	.14408
	AVG RESP	.99998	.99941	.99948	.99949	.99948	.99946	.99955
ALL	AVG SP D	[illegible]	.31602	.32211	.37316	.64675	1.26958	.52703
	AVG RESP	.93229	.89142	.87193	.84231	.76461	.70437	.83624

UNIFORM PRECISION COMBINATION DESIGN: 8 RADIAL AND 7 INNER VERTICES R2/R1= .337

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.05874	.08736	.12776	.18735	[illegible]	.13076
	AVG RESP	[illegible]	.96039	.93452	.87905	.79360	.68513	.87360
2	AVG SP D	[illegible]	.05657	.08460	.11871	.16491	.23126	.11625
	AVG RESP	[illegible]	.96526	.93370	.88298	.81049	.72240	.88295
3	AVG SP D	[illegible]	.04155	.05668	.08559	.12867	.18579	.08955
	AVG RESP	[illegible]	.98898	.98173	.96278	.92458	.85019	.95096
4	AVG SP D	.10644	.34114	1.25144	.49501	.77318	3.02960	.99979
	AVG RESP	.92443	.79665	.74322	.71831	.62525	.48153	.71490
5	AVG SP D	1.16499	1.00593	.96599	.98769	1.07769	1.32416	1.08774
	AVG RESP	.66553	.65772	.65188	.64602	.64013	.63421	.64891
6	AVG SP D	[illegible]	.18628	.17682	.17599	.17969	.18526	.15550
	AVG RESP	[illegible]	.99934	.99939	.99932	.99918	.99698	.99937
ALL	AVG SP D	.23557	[illegible]	.43698	.33179	.41857	.87531	.42993
	AVG RESP	[illegible]	.89572	.87407	.84837	.79887	.73007	.84511

UNIFORM PRECISION COMBINATION DESIGN: 8 RADIAL AND 8 INNER VERTICES R2/R1= .374

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04190	.06125	.09620	.13245	.19697	.30605	.13623
	AVG RESP	.98694	.96423	.93182	.87434	.78339	.66469	.86657
2	AVG SP D	.04194	.06066	.08600	.11964	.16236	.22207	.11546
	AVG RESP	.98692	.96255	.93076	.88087	.81029	.72348	.88148
3	AVG SP D	.03165	.03434	.05386	.08770	.12811	.17009	.08539
	AVG RESP	.99325	.99168	.98356	.96511	.93125	.87059	.95691
4	AVG SP D	.19696	.33940	.57015	.49651	.83953	2.84634	.86700
	AVG RESP	.92634	.79159	.73399	.71258	.60494	.44060	.70167
5	AVG SP D	1.50392	1.11270	.99172	.95091	.95284	.99167	1.08381
	AVG RESP	.67368	.66740	.66169	.65594	.65017	.64436	.65877
6	AVG SP D	.02798	.18446	.17514	.17896	.18634	.19559	.15804
	AVG RESP	.99999	.99935	.99931	.99912	.99882	.99644	.99917
ALL	AVG SP D	.29242	.29680	.32786	.32759	.41103	.79624	.40799
	AVG RESP	.92475	.89613	.87352	.84799	.79648	.72569	.84410

UNIFORM PRECISION COMBINATION DESIGN: 8 RADIAL AND 9 INNER VERTICES R2/R1= .401

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04450	.06755	.10224	.15598	.24789	.44409	.17704
	AVG RESP	.97912	.95880	.91829	.84215	.71521	.55626	.82864
2	AVG SP D	.04451	.06605	.09589	.13607	.19258	.28617	.13588
	AVG RESP	.97910	.95711	.91799	.85420	.76112	.64705	.85276
3	AVG SP D	.02331	.02967	.06554	.11368	.17734	.26370	.11254
	AVG RESP	.99465	.99208	.98142	.95651	.90677	.81711	.94146
4	AVG SP D	.10814	1.30456	.49729	.68893	6.06530	3.63760	2.05030
	AVG RESP	.91649	.74186	.70740	.65784	.52945	.42568	.60279
5	AVG SP D	2.97068	1.19113	.97458	.91900	.93177	1.01249	1.33478
	AVG RESP	.68158	.67626	.67095	.66564	.66035	.65507	.66831
6	AVG SP D	.02796	.16493	.16457	.17964	.20238	.23165	.16174
	AVG RESP	.99999	.99946	.99920	.99356	.99745	.99579	.99839
ALL	AVG SP D	.53602	.47650	.31668	.36555	1.30286	.97565	.60205
	AVG RESP	.92519	.88760	.86587	.82915	.76173	.68261	.82539

UNIFORM PRECISION COMBINATION DESIGN: 8 RADIAL AND 10 INNER VERTICES R2/R1= .420

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04714	.06670	.10241	.15554	.24624	.43579	.17597
	AVG RESP	.97744	.95610	.91902	.84492	.72062	.56536	.83091
2	AVG SP D	.04713	.06574	.09209	.12710	.17498	.24573	.12546
	AVG RESP	.97742	.95594	.91917	.86087	.77662	.67150	.86025
3	AVG SP D	.02606	.03632	.06280	.10145	.14658	.20633	.09359
	AVG RESP	.99468	.99046	.97890	.95621	.91736	.85703	.94911
4	AVG SP D	.10757	.56252	.48109	.72974	3.76193	7.64223	2.24768
	AVG RESP	.91289	.75665	.70203	.65058	.51645	.41768	.65975
5	AVG SP D	5.27343	1.08122	1.18146	.99822	.92732	.90412	1.80096
	AVG RESP	.68922	.68431	.67938	.67445	.66952	.66459	.67691
6	AVG SP D	.02795	.16349	.15752	.16278	.17124	.18113	.14402
	AVG RESP	.99999	.99919	.99940	.99916	.99883	.99641	.99921
ALL	AVG SP D	.92671	.46200	.34623	.37914	.90471	1.63469	.77461
	AVG RESP	.92627	.89092	.86632	.83103	.76690	.69579	.82936

UNIFORM PRECISION COMBINATION DESIGN: 9 RADIAL AND 6 INNER VERTICES R2/R1= .217

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03606	.05121	.07246	.10044	.13764	.18949	.09788
	AVG RESP	.99651	.97275	.94858	.90961	.85141	.77266	.90695
2	AVG SP D	.03605	.05623	.09537	.16153	.29066	.67006	.21975
	AVG RESP	.99651	.97586	.94950	.88845	.76646	.52635	.84822
3	AVG SP D	.05397	.11626	.31569	.45958	.70479	.49664	.35584
	AVG RESP	.97650	.95909	.87080	.78612	.80962	.79557	.80663
4	AVG SP D	[illegible]	.14676	.24173	.54354	.49653	.99255	.42208
	AVG RESP	[illegible]	.98103	.77196	.65520	.62828	.59205	.74365
5	AVG SP D	1.01700	1.09265	2.64858	1.35231	1.27267	27.23502	5.76971
	AVG RESP	.64441	.63665	.63282	.62690	.62086	.61476	.62973
6	AVG SP D	.02817	.22610	.22683	.28621	.53186	1.77241	.51260
	AVG RESP	.99998	.99694	.99830	.99445	.94058	.78505	.95255
ALL	AVG SP D	.21339	.28687	.60043	.48432	.57236	5.22649	1.22964
	AVG RESP	.97141	.90439	.86199	.81012	.70854	.68129	.82462

UNIFORM PRECISION COMBINATION DESIGN: 9 RADIAL AND 7 INNER VERTICES R2/R1= .295

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04780	.05355	.07429	.10054	.13428	.17940	.09665
	AVG RESP	.96651	.97014	.94602	.90851	.85425	.78204	.90767
2	AVG SP D	.03784	.05904	.09692	.15024	.26888	.53405	.19250
	AVG RESP	.93451	.97312	.94661	.88636	.77571	.59701	.86099
3	AVG SP D	.04772	.08045	.65685	.63185	1.09542	.67100	.63168
	AVG RESP	.98693	.97977	.85444	.77271	.76070	.74057	.64965
4	AVG SP D	.10735	.14298	.21418	.90691	.88651	.72902	.49782
	AVG RESP	.92869	.87967	.78709	.67948	.61884	.66011	.74898
5	AVG SP D	1.05881	.98799	1.22469	4.19191	1.21358	1.36698	1.65918
	AVG RESP	.65519	.64957	.64390	.63319	.63241	.62057	.64097
6	AVG SP D	.02808	.21747	.21671	.25479	.35390	.73067	.30028
	AVG RESP	.99998	.99903	.99655	.99624	.98486	.83695	.90827
ALL	AVG SP D	.21661	.25791	.41394	1.02556	.75877	.70232	.56302
	AVG RESP	.92330	.90855	.86277	.81402	.77113	.69678	.82942

UNIFORM PRECISION COMBINATION DESIGN: 9 RADIAL AND 8 INNER VERTICES R2/R1= .342

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03983	.05976	.08651	.12149	.16908	.23670	.11923
	AVG RESP	.99265	.96444	.93269	.88119	.80410	.70259	.87786
2	AVG SP D	.03982	.06041	.11437	.20170	.40334	3.97102	.79944
	AVG RESP	.99264	.96764	.93075	.84254	.65721	.37173	.79205
3	AVG SP D	.04261	.08374	.67052	.66885	1.04550	.94038	.57669
	AVG RESP	.99162	.98339	.81854	.72738	.74702	.71063	.83066
4	AVG SP D	.10652	.15098	.37669	.97544	.78198	1.66001	.70974
	AVG RESP	.92479	.85518	.73065	.61895	.59457	.56083	.71548
5	AVG SP D	1.13916	.95599	1.13735	3.10815	1.14740	1.75693	1.54867
	AVG RESP	.65464	.65940	.65418	.64896	.64374	.63651	.65157
6	AVG SP D	.02802	.19440	.23977	.44490	4.49454	1.22196	1.10393
	AVG RESP	.99098	.99904	.99603	.96047	.83028	.86625	.90901
ALL	AVG SP D	.24083	.25255	.43754	.92009	1.34032	1.66038	.80962
	AVG RESP	.92440	.90435	.84391	.77968	.67949	.64422	.79611

UNIFORM PRECISION COMBINATION DESIGN: 9 RADIAL AND 9 INNER VERTICES R2/R1= .374

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04197	.05997	.08249	.11082	.14738	.19602	.10656
	AVG RESP	.98091	.96595	.93624	.89359	.83190	.75614	.89279
2	AVG SP D	.04196	.06581	.10562	.17171	.29659	.63550	.21920
	AVG RESP	.98091	.96699	.93607	.86962	.73903	.52696	.83660
3	AVG SP D	.03852	.07127	.28619	.55449	.96117	1.76297	.61244
	AVG RESP	.99399	.98617	.86296	.77152	.69015	.66491	.82862
4	AVG SP D	.10627	.14695	.24511	3.35342	.50938	.60155	.82711
	AVG RESP	.92116	.86377	.76017	.65746	.59459	.57162	.72816
5	AVG SP D	1.50412	.95692	.96385	1.45332	1.59617	1.12548	1.20664
	AVG RESP	.67307	.66618	.66334	.65851	.65371	.64693	.66096
6	AVG SP D	.02798	.19117	.20122	.25359	.38086	.95739	.33637
	AVG RESP	.99099	.99922	.99841	.99480	.97515	.70694	.94475
ALL	AVG SP D	.29347	.24666	.31408	.98239	.64960	.67962	.50139
	AVG RESP	.92500	.90638	.85953	.80758	.74742	.64695	.81531

UNIFORM PRECISION COMBINATION DESIGN: 9 RADIAL AND 10 INNER VERTICES R2/R1= .398

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04422	.05771	.07399	.09365	.11773	.14797	.08921
	AVG RESP	.97929	.96487	.94299	.91149	.86835	.81265	.91327
2	AVG SP D	.04422	.06259	.09175	.13481	.19996	.38612	.14024
	AVG RESP	.97929	.96756	.94424	.90110	.82713	.71631	.88961
3	AVG SP D	.03477	.06157	.13818	.57269	.98762	1.60432	.56653
	AVG RESP	.99481	.99014	.95044	.78929	.67501	.52092	.82010
4	AVG SP D	.10637	.13537	.17875	.27328	3.45638	.64675	.79915
	AVG RESP	.91769	.87720	.81008	.73050	.60418	.61494	.76910
5	AVG SP D	2.62010	1.04156	.91534	.96038	1.28793	3.64692	1.77870
	AVG RESP	.69866	.67590	.67096	.66614	.66135	.65657	.66858
6	AVG SP D	.02796	.20270	.18202	.17808	.17786	.17925	.15798
	AVG RESP	.99099	.99925	.99939	.99940	.99938	.99954	.99946
ALL	AVG SP D	.47661	.25992	.26334	.36382	1.03791	1.12222	.58864
	AVG RESP	.92529	.91247	.88639	.83299	.78257	.72645	.84335

UNIFORM PRECISION COMBINATION DESIGN: 10 RADIAL AND 6 INNER VERTICES R2/R1= .129

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03604	.04946	.07690	.11385	.16340	.23420	.11214
	AVG RESP	.99778	.98149	.96425	.93096	.87412	.78601	.92120
2	AVG SP D	.03605	.04429	.07061	.14111	.26277	.60261	.19407
	AVG RESP	.99779	.98936	.97884	.94089	.83017	.55539	.88011
3	AVG SP D	.05901	.09569	.63956	.28383	.35618	.57738	.33476
	AVG RESP	.97676	.96031	.83470	.85323	.84166	.81654	.87983
4	AVG SP D	.11126	.10340	.12219	.15329	.19394	.24662	.15548
	AVG RESP	.93454	.92461	.89235	.84810	.79482	.73551	.85495
5	AVG SP D	1.02958	1.15873	2.34620	1.60548	1.19491	1.30318	1.44051
	AVG RESP	.63713	.63314	.62896	.62457	.61997	.61516	.62649
6	AVG SP D	.02875	.75658	.48491	.30785	.26672	.24678	.34921
	AVG RESP	.99998	.92618	.98828	.99131	.99354	.99447	.98095
ALL	AVG SP D	.21620	.36601	.60473	.43424	.48632	.53670	.43103
	AVG RESP	.91066	.90252	.87988	.86484	.82571	.75691	.85726

UNIFORM PRECISION COMBINATION DESIGN: 10 RADIAL AND 7 INNER VERTICES R2/R1= .246

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03650	.05426	.08829	.13735	.21155	.34251	.14509
	AVG RESP	.98590	.97079	.95233	.90184	.81069	.67554	.88385
2	AVG SP D	.03650	.05104	.09584	.19308	.46437	77.43072	13.04527
	AVG RESP	.98590	.98568	.96798	.89728	.64666	.21933	.78381
3	AVG SP D	.05139	.07811	1.27099	1.16285	5.20394	.34313	1.35174
	AVG RESP	.98169	.97590	.83792	.83324	.83540	.62936	.88325
4	AVG SP D	.10869	.10827	.13197	.17159	.23144	.32662	.17985
	AVG RESP	.93125	.91252	.87069	.81253	.74179	.66223	.82183
5	AVG SP D	1.02195	1.04327	1.67355	1.56021	1.14782	1.52001	1.32780
	AVG RESP	.64779	.64420	.64042	.63642	.63221	.62778	.63814
6	AVG SP D	.02814	10.52711	.34014	.25966	.23044	.22508	1.93623
	AVG RESP	.99996	.64631	.99112	.99466	.99563	.99607	.93763
ALL	AVG SP D	.21389	1.97701	.60013	.58034	1.24926	13.36465	2.99766
	AVG RESP	.92209	.85723	.87674	.84700	.77706	.66038	.82475

UNIFORM PRECISION COMBINATION DESIGN: 10 RADIAL AND 8 INNER VERTICES R2/R1= .306

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03425	.05591	.08420	.12632	.18574	.27796	.12773
	AVG RESP	.98413	.97608	.95494	.91354	.84155	.73029	.90059
2	AVG SP D	.03425	.05106	.08903	.16644	.34128	1.36104	.34126
	AVG RESP	.98413	.98504	.97139	.92005	.75585	.30044	.81948
3	AVG SP D	.04564	.06295	.71481	.61432	.54296	.41199	.39881
	AVG RESP	.98026	.98516	.81321	.64976	.61941	.60906	.87611
4	AVG SP D	.10736	.10591	.12789	.16364	.21245	.28256	.16663
	AVG RESP	.92775	.91088	.87350	.82301	.76283	.69573	.83228
5	AVG SP D	1.07660	.97730	1.19894	3.20335	1.32938	1.11016	1.40862
	AVG RESP	.65717	.65593	.65053	.64597	.64324	.63903	.64853
6	AVG SP D	.02807	1.77337	.39085	.27506	.24489	.23106	.49063
	AVG RESP	.99998	.66083	.98790	.99373	.99510	.99570	.93887
ALL	AVG SP D	.22239	.50408	.41929	.75818	.47612	.61603	.49895
	AVG RESP	.92357	.86199	.87524	.85634	.80300	.69572	.83598

UNIFORM PRECISION COMBINATION DESIGN: 10 RADIAL AND 9 INNER VERTICES R2/R1= .346

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04003	.05159	.07487	.10519	.14246	.18999	.10069
	AVG RESP	.98247	.97687	.96211	.93596	.89479	.83305	.93121
2	AVG SP D	.04003	.04847	.07473	.12236	.20333	.36105	.14176
	AVG RESP	.98247	.98544	.97806	.95187	.88546	.73394	.91954
3	AVG SP D	.04137	.05335	.12566	.88165	.75016	2.02220	.64574
	AVG RESP	.99211	.99016	.96666	.74202	.75474	.74506	.86489
4	AVG SP D	.10671	.10137	.11967	.14578	.17918	.21601	.14534
	AVG RESP	.92431	.91307	.88477	.84838	.80648	.76136	.85039
5	AVG SP D	1.29887	.98450	.96523	1.08690	1.33686	1.93006	1.33541
	AVG RESP	.66553	.66230	.65895	.65548	.65189	.64816	.65705
6	AVG SP D	.02902	.45085	.70496	.34417	.28357	.25932	.34515
	AVG RESP	.99996	.98027	.96262	.98923	.99266	.99395	.98045
ALL	AVG SP D	.24417	.28169	.34419	.44784	.56594	.83026	.45235
	AVG RESP	.92448	.91602	.90219	.85382	.83101	.78002	.86926

UNIFORM PRECISION COMBINATION DESIGN: 10 RADIAL AND 10 INNER VERTICES R2/R1= .374

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04196	.05155	.07269	.09877	.12875	.16400	.09295
	AVG RESP	.98092	.97617	.96332	.94180	.90994	.86097	.93968
2	AVG SP D	.04196	.04659	.07168	.11121	.17193	.27105	.11945
	AVG RESP	.98092	.98490	.97902	.95830	.91112	.81502	.93826
3	AVG SP D	.03776	.04874	.10446	.37225	1.03927	.80055	.40151
	AVG RESP	.99416	.99282	.97898	.79236	.67059	.67502	.85040
4	AVG SP D	.10549	.09962	.11746	.14165	.16869	.19679	.13879
	AVG RESP	.92101	.91183	.88677	.85571	.82094	.78427	.86342
5	AVG SP D	1.50498	1.03823	.96655	.96495	1.11505	1.92601	1.24926
	AVG RESP	.67307	.66960	.66604	.66238	.65860	.65472	.66407
6	AVG SP D	.02799	.36498	1.62483	.41501	.32198	.28751	.50702
	AVG RESP	.99999	.98668	.83072	.98423	.99019	.99222	.96434
ALL	AVG SP D	.29355	.27528	.48957	.35864	.49061	.60934	.41816
	AVG RESP	.92501	.92067	.88414	.86579	.82690	.79767	.87003

ORTHOGONAL COMBINATION DESIGN: 5 RADIAL AND 6 INNER VERTICES R2/R1= .204

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06697	.05678	.05964	.06941	.08746	.11605	.07639
	AVG RESP	.96846	.99256	.98751	.98557	.97576	.95366	.97579
2	AVG SP D	.06224	.06152	.07232	.09030	.11585	.14608	.09185
	AVG RESP	.97159	.97307	.96409	.94669	.92040	.88446	.94338
3	AVG SP D	.10402	.10191	.10554	.11906	.22271	.14600	.13221
	AVG RESP	.95580	.95143	.94697	.93545	.87980	.90605	.92848
4	AVG SP D	.74723	.40725	.24835	.25974	.33523	.27029	.37802
	AVG RESP	.77368	.82350	.85082	.87094	.89248	.88840	.85097
5	AVG SP D	.39538	.40169	.42009	.44109	.46537	.49394	.43459
	AVG RESP	.70061	.70138	.69259	.68323	.67329	.66262	.68716
6	AVG SP D	.03124	.16138	.45371	1.54768	1.10167	.42020	.62035
	AVG RESP	.99996	.99906	.96569	.85939	.75264	.96715	.92407
ALL	AVG SP D	.23785	.19676	.22661	.42125	.38605	.26509	.28890
	AVG RESP	.89570	.90517	.90128	.88126	.84906	.87737	.88497

ORTHOGONAL COMBINATION DESIGN: 5 RADIAL AND 7 INNER VERTICES R2/R1= .266

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.06984	.06505	.07153	.09022	.12613	.19023	.10216
	AVG RESP	.96470	.97610	.98160	.97352	.94725	.86126	.95447
2	AVG SP D	.06554	.06087	.08590	.11590	.15390	.21253	.11577
	AVG RESP	.96790	.96549	.94977	.91900	.87414	.81009	.91598
3	AVG SP D	.14380	.11466	.10858	.10946	.11484	.12596	.11923
	AVG RESP	.92154	.94063	.94196	.93460	.92207	.90438	.92753
4	AVG SP D	1.03768	.20531	.27129	.33782	.26565	.21963	.40293
	AVG RESP	.76384	.80953	.82776	.85546	.87513	.89017	.83865
5	AVG SP D	.38876	.40243	.41779	.43560	.45466	.47720	.42929
	AVG RESP	.71673	.69940	.69171	.68369	.67539	.66673	.68731
6	AVG SP D	.03126	.19192	1.18481	2.36515	.46043	.33760	.76189
	AVG RESP	.99698	.99630	.89011	.56570	.95914	.98411	.90289
ALL	AVG SP D	.27949	.18804	.35663	.57526	.26260	.26026	.32205
	AVG RESP	.87747	.89657	.88215	.82551	.87552	.85759	.87114

ORTHOGONAL COMBINATION DESIGN: 5 RADIAL AND 8 INNER VERTICES R2/R1= .304

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07249	.05948	.05714	.06507	.08730	.12444	.07765
	AVG RESP	.96159	.98167	.98664	.98541	.97287	.95039	.97343
2	AVG SP D	.06953	.06691	.08455	.10439	.12759	.15416	.10135
	AVG RESP	.96479	.96037	.95674	.93973	.91677	.88005	.93884
3	AVG SP D	.15388	.15223	.11158	.11212	.12739	.51262	.19497
	AVG RESP	.92258	.91681	.93478	.92754	.90788	.87137	.91349
4	AVG SP D	1.47564	.32076	.33581	.34341	.30859	.42005	.55314
	AVG RESP	.75548	.80139	.82740	.83808	.85715	.85502	.82219
5	AVG SP D	.39273	.41259	.43552	.46257	.49442	.53303	.45521
	AVG RESP	.70403	.69420	.68388	.67319	.66235	.65107	.67822
6	AVG SP D	.03130	.14079	.25957	.53736	5.94251	5.81342	2.12182
	AVG RESP	.99990	.99909	.99526	.97941	.76601	.51706	.87627
ALL	AVG SP D	.36576	.21146	.21403	.27078	1.18130	1.26062	.58403
	AVG RESP	.88474	.89526	.89779	.89066	.84717	.78063	.86707

ORTHOGONAL COMBINATION DESIGN: 5 RADIAL AND 9 INNER VERTICES R2/R1= .336

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07482	.06259	.05927	.06482	.08037	.11065	.07542
	AVG RESP	.95279	.97028	.98664	.98610	.97751	.96073	.97467
2	AVG SP D	.07119	.06851	.08078	.09880	.12058	.14576	.09760
	AVG RESP	.96199	.96532	.95860	.94485	.92537	.90079	.94282
3	AVG SP D	.11597	.13375	.41736	.13401	.11882	.12208	.17372
	AVG RESP	.93780	.92204	.90398	.90328	.91372	.90370	.91409
4	AVG SP D	1.88787	.33280	.27756	.27492	.32545	.38038	.57986
	AVG RESP	.74915	.78532	.82823	.84167	.82636	.80379	.80592
5	AVG SP D	.39750	.41415	.43292	.45433	.47904	.50003	.44766
	AVG RESP	.70147	.69363	.68549	.67713	.66865	.66021	.68110
6	AVG SP D	.03134	.13841	.23169	.40571	.77928	3.70192	.88139
	AVG RESP	.99996	.99919	.99625	.98732	.95739	.75241	.94876
ALL	AVG SP D	.42078	.19170	.24993	.23876	.31726	.82022	.37594
	AVG RESP	.86470	.89063	.89320	.89006	.87650	.83027	.87789

ORTHOGONAL COMBINATION DESIGN: 5 RADIAL AND 10 INNER VERTICES R2/R1= .346

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07686	.06480	.06238	.06983	.09034	.11652	.08046
	AVG RESP	.95631	.97632	.98449	.98355	.97439	.95600	.97194
2	AVG SP D	.07355	.06922	.07859	.09690	.12085	.14953	.09811
	AVG RESP	.95950	.96480	.95877	.94455	.92332	.89359	.94109
3	AVG SP D	.11616	.11601	.12695	.17850	.18918	.24058	.16273
	AVG RESP	.93549	.93098	.91984	.87332	.88056	.87058	.90265
4	AVG SP D	1.95748	.32583	.30931	.39635	.77338	2.54098	1.05089
	AVG RESP	.74157	.77782	.82215	.77950	.76040	.74416	.77093
5	AVG SP D	.40253	.41659	.43665	.45717	.48077	.50052	.45067
	AVG RESP	.69902	.69203	.68491	.67740	.66990	.66243	.68093
6	AVG SP D	.03137	.13572	.22695	.40583	.84100	5.15357	1.13238
	AVG RESP	.99998	.99921	.99626	.98657	.94801	.45719	.89787
ALL	AVG SP D	.44263	.19670	.20680	.26774	.41592	1.45325	.49587
	AVG RESP	.83198	.89004	.89439	.87415	.85943	.76342	.86090

ORTHOGONAL COMBINATION DESIGN: 6 RADIAL AND 7 INNER VERTICES R2/R1= .189

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03310	.04161	.06563	.09624	.13341	.17929	.09153
	AVG RESP	.99709	.98946	.98268	.96604	.93674	.89029	.95872
2	AVG SP D	.04293	.05016	.06690	.08436	.10107	.11635	.07691
	AVG RESP	.99495	.98103	.97216	.95935	.94261	.92107	.96030
3	AVG SP D	.17009	.12561	.10072	.08731	.08178	.08217	.10944
	AVG RESP	.96613	.97296	.97586	.97456	.97086	.96306	.96907
4	AVG SP D	.11907	.16012	.40405	.36662	.48081	1.16096	.44927
	AVG RESP	.92770	.91640	.83536	.85554	.82961	.74018	.85080
5	AVG SP D	11.37097	1.06939	.99160	1.75308	1.21266	1.06604	2.90976
	AVG RESP	.64645	.64691	.64738	.64786	.64835	.64005	.64763
6	AVG SP D	.02067	3.36308	.96662	.49163	.40109	.36244	.93559
	AVG RESP	.99996	.87160	.85903	.98007	.98814	.99609	.94825
ALL	AVG SP D	1.96130	.80166	.43259	.47932	.40180	.49353	.76208
	AVG RESP	.91688	.89539	.87875	.89724	.88605	.86645	.88913

ORTHOGONAL COMBINATION DESIGN: 6 RADIAL AND 8 INNER VERTICES R2/R1= .250

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03837	.04452	.06849	.10031	.13967	.18959	.09649
	AVG RESP	.98494	.98721	.98004	.96193	.92934	.87715	.95343
2	AVG SP D	.04275	.05063	.06650	.08308	.10120	.11930	.07734
	AVG RESP	.98275	.97067	.96950	.95599	.93812	.91306	.95678
3	AVG SP D	.17326	.12550	.10086	.08605	.08052	.08070	.10792
	AVG RESP	.96855	.97697	.98244	.98106	.97665	.96958	.97521
4	AVG SP D	.11548	.15016	.53878	.40195	.50377	1.30061	.50279
	AVG RESP	.92235	.91020	.81402	.83856	.80400	.71597	.83385
5	AVG SP D	2.02684	.98757	.96154	1.55975	1.31552	.99308	1.30565
	AVG RESP	.65983	.65836	.65893	.65904	.65920	.65959	.65904
6	AVG SP D	.02857	3.04394	.98062	.51757	.42624	.37906	.97789
	AVG RESP	.99096	.85184	.96195	.97555	.98702	.98973	.94485
ALL	AVG SP D	.40748	.81606	.45280	.45035	.42682	.51057	.51135
	AVG RESP	.91856	.89429	.87781	.89536	.88239	.85425	.88719

ORTHOGONAL COMBINATION DESIGN: 6 RADIAL AND 9 INNER VERTICES R2/R1= .287

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03960	.04536	.06713	.09734	.13539	.18375	.09477
	AVG RESP	.99294	.98635	.98039	.96389	.93386	.88003	.95555
2	AVG SP D	.04443	.05064	.06572	.08245	.09953	.11709	.07664
	AVG RESP	.98869	.97763	.96935	.95880	.94013	.91321	.95730
3	AVG SP D	.17154	.12452	.09165	.08308	.07759	.07701	.10563
	AVG RESP	.96724	.98056	.98450	.98304	.97820	.97052	.97668
4	AVG SP D	.11625	.14507	.54322	.53390	.71965	1.18202	.54835
	AVG RESP	.91741	.91744	.80292	.78222	.76366	.72434	.81610
5	AVG SP D	1.33979	.92529	.96794	2.56030	1.10702	.96000	1.31111
	AVG RESP	.66643	.66909	.66885	.66871	.66866	.66809	.66891
6	AVG SP D	.02852	1.35316	17.02896	.76549	.54897	.47005	3.36596
	AVG RESP	.99998	.82425	.46171	.92843	.97192	.98069	.86119
ALL	AVG SP D	.29803	.44034	3.12861	.69551	.44802	.49995	.91708
	AVG RESP	.91895	.89255	.81129	.88052	.87607	.85505	.87295

ORTHOGONAL COMBINATION DESIGN: 6 RADIAL AND 10 INNER VERTICES R2/R1= .314

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.04288	.04692	.06770	.09884	.14005	.19442	.09847
	AVG RESP	.98104	.98531	.97955	.96199	.92836	.87211	.95139
2	AVG SP D	.04609	.05161	.06729	.08511	.10349	.12201	.07937
	AVG RESP	.97877	.97692	.96744	.95411	.93613	.91302	.95430
3	AVG SP D	.17308	.12338	.09611	.08057	.07390	.07378	.10347
	AVG RESP	.95997	.97964	.98456	.98345	.97867	.97391	.97620
4	AVG SP D	.11711	.14767	1.16329	.50881	.66924	.67926	.54723
	AVG RESP	.91275	.91154	.79975	.77998	.75835	.71316	.81293
5	AVG SP D	1.10794	.88117	1.00788	5.37371	.97532	.97914	1.72171
	AVG RESP	.67892	.67635	.67793	.67765	.67751	.67748	.67797
6	AVG SP D	.02848	1.12642	10.83646	.74809	.51490	.43062	2.28083
	AVG RESP	.99998	.94033	.53802	.92083	.97136	.98098	.89192
ALL	AVG SP D	.25244	.39620	2.20645	1.14886	.41282	.41430	.80518
	AVG RESP	.91857	.91196	.92454	.87967	.87507	.85499	.87745

ORTHOGONAL COMBINATION DESIGN: 7 RADIAL AND 8 INNER VERTICES R2/R1= .176

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03648	.05166	.08315	.12724	.18993	.28847	.12916
	AVG RESP	.98633	.97683	.95731	.91328	.83855	.72445	.90012
2	AVG SP D	.03616	.05154	.07169	.09492	.12240	.15621	.08881
	AVG RESP	.98636	.97575	.95245	.92018	.87498	.81703	.92079
3	AVG SP D	.14886	.23071	.12631	.09836	.09095	.09203	.13087
	AVG RESP	.92752	.86872	.94296	.95505	.93743	.91828	.92333
4	AVG SP D	.11884	.72016	.40820	.45268	.83355	2.81380	.85870
	AVG RESP	.92699	.77474	.79706	.78840	.66818	.49944	.74180
5	AVG SP D	1.00285	1.04141	1.15375	1.46273	3.35972	2.49363	1.75235
	AVG RESP	.64595	.64274	.63942	.63399	.63245	.62861	.63756
6	AVG SP D	.02817	.23829	.21031	.20890	.20534	.20378	.18230
	AVG RESP	.99998	.99672	.99675	.99359	.99844	.99932	.99880
ALL	AVG SP D	.23656	.38596	.34222	.40664	.76098	1.00862	.52370
	AVG RESP	.91219	.87258	.88132	.86792	.82467	.76372	.85373

ORTHOGONAL COMBINATION DESIGN: 7 RADIAL AND 9 INNER VERTICES R2/R1= .235

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03817	.05523	.09466	.12945	.19401	.29473	.13238
	AVG RESP	.98444	.97704	.95533	.91864	.83242	.72220	.89701
2	AVG SP D	.03785	.05270	.07283	.09612	.12351	.15763	.09001
	AVG RESP	.98446	.97144	.94976	.91732	.87235	.81310	.91940
3	AVG SP D	.15170	16.41192	.11051	.09811	.09339	.09421	2.83312
	AVG RESP	.98303	.87593	.95032	.95424	.93084	.91030	.92264
4	AVG SP D	.11912	1.77617	.44489	.53310	.69853	3.87959	1.24120
	AVG RESP	.92278	.75713	.78974	.77350	.65410	.47957	.73030
5	AVG SP D	.99709	1.08059	1.35174	3.01738	2.28994	1.30395	1.67178
	AVG RESP	.65701	.65364	.65016	.64557	.64288	.63909	.64823
6	AVG SP D	.02810	.24776	.21447	.20860	.20736	.20742	.18562
	AVG RESP	.99999	.99654	.99861	.99844	.99828	.99314	.99867
ALL	AVG SP D	.23184	3.27039	.38135	.68129	.59979	.98944	1.02568
	AVG RESP	.90045	.87229	.88232	.86762	.82281	.76077	.85254

ORTHOGONAL COMBINATION DESIGN: 7 RADIAL AND 10 INNER VERTICES R2/R1= .275

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03054	.05630	.09106	.14524	.23257	.40000	.16092
	AVG RESP	.98260	.97066	.94767	.89054	.78355	.62001	.86773
2	AVG SP D	.03955	.05481	.07[illegible]	.10178	.13377	.17544	.09688
	AVG RESP	.98267	.96759	.94233	.90361	.84843	.77008	.90354
3	AVG SP D	.22453	1.81471	.13669	.11041	.10348	.10290	.41629
	AVG RESP	.83214	.86519	.92954	.94298	.92850	.90346	.90863
4	AVG SP D	.11790	.52760	.44546	.07250	.09411	21.33115	3.99813
	AVG RESP	.91873	.76281	.77306	.72318	.60326	.43405	.70360
5	AVG SP D	.99173	1.10519	1.38499	2.65240	3.43496	1.49558	1.84411
	AVG RESP	.66676	.66050	.66014	.65670	.65316	.64903	.65830
6	AVG SP D	.02905	.21290	.10901	.18579	.18600	.16705	.16480
	AVG RESP	.99098	.99693	.99839	.99871	.99853	.99658	.99890
ALL	AVG SP D	.24110	.62658	.38719	.64470	.83082	3.94674	1.11352
	AVG RESP	.90549	.87195	.87527	.85362	.80257	.73100	.84012

ORTHOGONAL COMBINATION DESIGN: 8 RADIAL AND 9 INNER VERTICES R2/R1= .167

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03691	.05280	.07988	.11304	.17602	.26994	.12220
	AVG RESP	.98669	.97210	.94982	.88989	.80450	.68928	.88088
2	AVG SP D	.03803	.05522	.07771	.11087	.15716	.22069	.11028
	AVG RESP	.98667	.97114	.94197	.89264	.81783	.72003	.88848
3	AVG SP D	.05361	.05506	.06623	.08499	.11371	.15671	.08872
	AVG RESP	.97494	.97066	.97331	.95970	.92646	.86221	.94554
4	AVG SP D	.11327	1.30931	.58839	.49661	1.53200	2.53978	1.09656
	AVG RESP	.93640	.76800	.77634	.74621	.67853	.54704	.74119
5	AVG SP D	1.00638	1.03724	1.15392	1.51320	6.45870	1.85091	2.17139
	AVG RESP	.64455	.63938	.63421	.62903	.62386	.61868	.63162
6	AVG SP D	.02820	.17127	.15827	.15497	.15393	.15362	.13674
	AVG RESP	.99098	.99947	.99955	.99956	.99956	.99905	.99961
ALL	AVG SP D	.21223	.44648	.35406	.41321	1.43192	.86797	.62098
	AVG RESP	.92055	.88779	.87803	.85284	.80846	.73906	.84789

ORTHOGONAL COMBINATION DESIGN: 8 RADIAL AND 10 INNER VERTICES R2/R1= .225

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03742	.05381	.07964	.11617	.16913	.25242	.11810
	AVG RESP	.98504	.97079	.94295	.89373	.81521	.70659	.88605
2	AVG SP D	.03752	.05413	.07711	.10735	.14791	.20556	.10493
	AVG RESP	.98502	.96955	.94184	.89668	.82980	.74291	.89430
3	AVG SP D	.04830	.05021	.06010	.07522	.09618	.12496	.07583
	AVG RESP	.98374	.98438	.98025	.96758	.94218	.89751	.95932
4	AVG SP D	.11276	2.41228	.92084	5.52147	.67917	3.96047	2.26883
	AVG RESP	.92669	.79209	.77265	.74308	.66133	.55058	.74240
5	AVG SP D	.98888	.98205	1.01569	1.10179	1.29718	1.91654	1.21707
	AVG RESP	.65439	.64937	.64434	.63929	.63424	.62918	.64180
6	AVG SP D	.02813	.17300	.16153	.15891	.15878	.15959	.14032
	AVG RESP	.99098	.99945	.99952	.99951	.99947	.99943	.99956
ALL	AVG SP D	.20884	.62125	.38582	1.18015	.42472	1.10431	.65418
	AVG RESP	.92248	.89427	.88026	.85669	.81371	.75003	.85391

ORTHOGONAL COMBINATION DESIGN: 9 RADIAL AND 10 INNER VERTICES R2/R1= .156

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03593	.04694	.06098	.07815	.09925	.12563	.07448
	AVG RESP	.98685	.97691	.96090	.93705	.90353	.85920	.93741
2	AVG SP D	.03592	.04906	.07479	.11258	.16887	.25958	.11680
	AVG RESP	.98685	.98604	.96451	.93355	.87654	.78573	.92087
3	AVG SP D	.05567	.09716	.30759	.38834	.55337	.39403	.29936
	AVG RESP	.97748	.96586	.87211	.79283	.77357	.78507	.86115
4	AVG SP D	.11123	.12584	.14514	.17093	.20575	.25731	.16937
	AVG RESP	.93216	.90680	.87369	.83176	.77936	.71912	.84048
5	AVG SP D	1.08963	1.09907	1.70573	2.10263	1.24841	1.32455	1.41501
	AVG RESP	.64339	.63612	.63279	.62738	.62191	.61657	.62999
6	AVG SP D	.02821	.29094	.23725	.22360	.21967	.21998	.20316
	AVG RESP	.99098	.99847	.99873	.99857	.99827	.99769	.99665
ALL	AVG SP D	.21276	.28469	.42191	.51274	.41589	.43018	.37970
	AVG RESP	.93112	.91103	.88379	.85352	.82553	.79356	.86476

ORTHOGONAL COMBINATION DESIGN: [illegible] RADIAL AND [illegible] INNER VERTICES R2/R1= .581

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.06532	.05907	.05433	.05431	.05630	.06350
	AVG RESP	[illegible]	.97701	[illegible]	.97952	.96858	.98522	.97975
2	AVG SP D	[illegible]	.06513	[illegible]	.07150	.08195	.09137	.07719
	AVG RESP	[illegible]	[illegible]	[illegible]	.97082	.96753	.95383	.96599
3	AVG SP D	[illegible]	.59250	[illegible]	.13529	.12151	.12722	.25497
	AVG RESP	[illegible]	[illegible]	[illegible]	.92937	.94663	.94795	.92996
4	AVG SP D	[illegible]	[illegible]	[illegible]	.35316	.61279	.79549	.50950
	AVG RESP	[illegible]	.74154	[illegible]	.52352	.80341	.78713	.77257
5	AVG SP D	[illegible]	.52033	[illegible]	.59810	.99051	1.74149	.82129
	AVG RESP	.67151	.65598	.64546	.53980	.60678	.49929	.61797
6	AVG SP D	.03120	.11345	.12568	.12609	.12783	.12137	.10944
	AVG RESP	[illegible]	.99975	.99975	.99974	.99972	[illegible]	.99978
ALL	AVG SP D	[illegible]	.25233	[illegible]	.25574	.31482	.48399	.30515
	AVG RESP	[illegible]	.87539	[illegible]	[illegible]	[illegible]	[illegible]	.87750

MINIMUM BIAS COMBINATION DESIGN: 5 RADIAL AND 6 INNER VERTICES R2/R1= .597

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07793	.07354	.06791	.06997	.07883	.09189	.07434
	AVG RESP	.95064	.97359	.98255	.94935	.97637	.96615	.97199
2	AVG SP D	.08558	.07555	.08151	.[illegible]	.11071	.12631	.09560
	AVG RESP	.95353	.95127	.95725	.94898	.93616	.92243	.94647
3	AVG SP D	.10419	.10405	.11314	.14035	.12699	.12689	.12156
	AVG RESP	.96133	.95449	.96066	.94859	.94879	.95367	.95464
4	AVG SP D	.59924	.58075	.69352	.91493	.34608	.32607	.55573
	AVG RESP	.67555	.74075	.76799	.81439	.83861	.84652	.78512
5	AVG SP D	.59753	.71154	.94355	5.97602	2.96395	2.21991	2.15906
	AVG RESP	.59213	.64235	.65497	.57956	.51583	.50971	.58739
6	AVG SP D	.03355	.13901	.15734	.17219	.25291	.39135	.19314
	AVG RESP	.99998	.99963	.99925	.99835	.99606	.98760	.99682
ALL	AVG SP D	.26234	.33121	.34293	1.14951	.56956	.54690	.53324
	AVG RESP	.85504	.88040	. 8710	.87597	.86864	.86418	.87374

MINIMUM BIAS COMBINATION DESIGN: 5 RADIAL AND 7 INNER VERTICES R2/R1= .607

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.09006	.07067	. 7593	.07793	.09643	.10544	.08543
	AVG RESP	.94950	.95765	.97614	.97551	.97994	.95741	.96508
2	AVG SP D	.09355	.05363	.09431	.11431	.13448	.15467	.11168
	AVG RESP	.95167	.95934	.95018	.97916	.92480	.90716	.93910
3	AVG SP D	.11094	.10353	.10242	.10925	.12698	.17459	.12212
	AVG RESP	.95122	.95449	.96563	.[illegible]	.95025	.92909	.95362
4	AVG SP D	.31475	8.19528	.66457	.96391	.39227	.35326	1.81416
	AVG RESP	.55769	.71194	.74974	.77651	.80372	.82419	.75547
5	AVG SP D	.71542	.85298	1.19783	9.47259	2.33101	3.01084	2.93191
	AVG RESP	.64532	.64298	.63954	.58848	.53885	.54089	.59951
6	AVG SP D	.03043	.13438	.17139	.22825	.32472	.49949	.23128
	AVG RESP	.99999	.99950	.99852	.99522	.99116	.97954	.99415
ALL	AVG SP D	.30439	1.57576	.38433	1.74427	.56598	.71587	.88276
	AVG RESP	.86095	.87349	.87996	.87321	.86314	.85529	.86782

MINIMUM BIAS COMBINATION DESIGN: 5 RADIAL AND 8 INNER VERTICES R2/R1= .613

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.09191	.05567	.05691	.06236	.07897	.09787	.07578
	AVG RESP	.94749	.97509	.98727	.98836	.98371	.97589	.97646
2	AVG SP D	.09097	.07182	.06326	.09567	.10746	.11388	.09468
	AVG RESP	.95321	.95229	.96371	.96067	.95556	.94941	.95697
3	AVG SP D	.82474	.10730	.10609	.13951	.15832	.15938	.24891
	AVG RESP	.92523	.96099	.96164	.93735	.93020	.92929	.94131
4	AVG SP D	1.27075	.52081	2.57759	2.09471	.43702	.33429	1.12419
	AVG RESP	.65790	.67515	.66501	.73910	.75954	.78733	.71612
5	AVG SP D	.94529	4.23092	2.59875	2.65251	2.34597	1.68577	2.39470
	AVG RESP	.64594	.63185	.55277	.54369	.53946	.51993	.57962
6	AVG SP D	.03432	.13494	.17622	.20729	.23157	.25100	.17189
	AVG RESP	.99998	.99913	.99792	.99674	.99570	.99480	.99738
ALL	AVG SP D	.54199	.85541	.23647	.87519	.55959	.44120	.68503
	AVG RESP	.85479	.86775	.85822	.85948	.85919	.85944	.85981

MINIMUM BIAS COMBINATION DESIGN: 5 RADIAL AND 9 INNER VERTICES R2/R1= .619

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.09369	.05826	.05720	.05643	.06236	.07293	.06848
	AVG RESP	.94926	.97141	.98419	.98913	.98926	.98633	.97775
2	AVG SP D	.09394	.07419	.07405	.08432	.09483	.10505	.08758
	AVG RESP	.94590	.96495	.97223	.97415	.97276	.96930	.96705
3	AVG SP D	.30081	.38475	.10815	.10201	.11081	.12625	.19096
	AVG RESP	.91126	.93594	.96133	.96646	.96218	.95242	.94820
4	AVG SP D	5.60670	.83597	.21051	.21534	.18838	.17472	1.30360
	AVG RESP	.67747	.85375	.75219	.85459	.90091	.92449	.78996
5	AVG SP D	2.39286	3.72451	34.26737	2.69568	2.24639	1.99508	7.87033
	AVG RESP	.64509	.50259	.57080	.56959	.56433	.55463	.59506
6	AVG SP D	.03622	.12607	.15410	.19129	.19688	.20986	.15923
	AVG RESP	.[illegible]	.99930	.[illegible]	.99756	.99684	.99522	.99805
ALL	AVG SP D	1.[illegible]	.86967	5.[illegible]2923	.59567	.48328	.44565	1.61186
	AVG RESP	.[illegible]	.85464	.[illegible]	.89175	.89771	.89723	.87751

MINIMUM BIAS COMBINATION DESIGN: 5 RADIAL AND 10 INNER VERTICES R2/R1= .620

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.09632	.07215	.06655	.07147	.07931	.08799	.07878
	AVG RESP	.94517	.95962	.97942	.98305	.98254	.97933	.97306
2	AVG SP D	.09187	.07491	.07533	.09417	.09916	.11501	.09158
	AVG RESP	.94773	.95695	. 7331	.97391	.97018	.96350	.96578
3	AVG SP D	.11453	.10947	.19511	.14674	.17692	.12496	.14247
	AVG RESP	.90624	.95717	.94306	.93375	.92841	.95507	.94642
4	AVG SP D	2.93415	1.32022	.[illegible]377	.22431	.21015	.20104	.85627
	AVG RESP	.63724	.65915	.75069	.82539	.85889	.87654	.76965
5	AVG SP D	2.35315	2.28092	2.60030	2.15342	1.88775	2.14895	2.23925
	AVG RESP	.57799	.59562	.58809	.58598	.57939	.57569	.58429
6	AVG SP D	.03513	.12563	.16317	.19799	.23021	.25972	.16782
	AVG RESP	.[illegible]	.[illegible]	.99837	.99705	.99557	.99404	.99740
ALL	AVG SP D	.[illegible]	.65072	.60271	.49035	.44725	.48945	.59586
	AVG RESP	.[illegible]	.85992	.87215	.88419	.88593	.89071	.87277

MINIMUM BIAS COMBINATION DESIGN: 6 RADIAL AND 5 INNER VERTICES R2/R1= .560

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.05549	[illegible]	.12017	.17571	.24003	.12644
	AVG RESP	[illegible]	.97859	[illegible]	[illegible]	.89391	.82092	.92951
2	AVG SP D	[illegible]	.05710	[illegible]	[illegible]	.11794	.13483	.09016
	AVG RESP	.97460	.97045	.95854	.94149	.91982	.89337	.94305
3	AVG SP D	[illegible]	.51953	1.35299	.16621	.13616	.12696	.49616
	AVG RESP	.75114	.76572	.77845	[illegible]	.96291	.96407	.85704
4	AVG SP D	.11703	.15630	.61446	1.64002	1.27436	1.04673	.80815
	AVG RESP	[illegible]	.90838	.71119	.71046	.68782	.58255	.75126
5	AVG SP D	[illegible]	2.51512	1.14660	1.56616	.98480	.80918	1.31692
	AVG RESP	[illegible]	.67924	[illegible]	.68459	.68734	.69015	.68332
6	AVG SP D	[illegible]	2.73109	.56022	[illegible]	.29271	.27243	.70414
	AVG RESP	.99999	.34583	.56490	.99225	.99474	.99560	.98238
ALL	AVG SP D	[illegible]	1.09725	[illegible]	.57204	.49711	.93903	.59031
	AVG RESP	.87733	.87520	[illegible]	.86505	.85775	.82444	.85776

MINIMUM BIAS COMBINATION DESIGN: 6 RADIAL AND 6 INNER VERTICES R2/R1= .581

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.07521	.10328	.15845	.21554	.30829	.15330
	AVG RESP	[illegible]	.97147	[illegible]	.91849	.84600	.74449	.90147
2	AVG SP D	[illegible]	.05216	[illegible]	[illegible]	.12701	.15189	.09729
	AVG RESP	[illegible]	.95791	[illegible]	[illegible]	.91541	.87495	.93641
3	AVG SP D	.71871	.72440	[illegible]	1.24215	.52464	8.30533	1.99960
	AVG RESP	[illegible]	.76518	.79654	.79126	.75654	.74760	.76852
4	AVG SP D	.11546	.15576	.39656	1.49543	11.09452	1.78619	2.50210
	AVG RESP	[illegible]	.39415	.72462	.53690	.58902	.49139	.70771
5	AVG SP D	7.03474	1.02749	.55795	.91957	1.83097	1.22700	2.15045
	AVG RESP	.69533	.69596	.70440	[illegible]	.70754	.71115	.70221
6	AVG SP D	.02515	1.75397	.51032	.55004	.32070	.30382	.54767
	AVG RESP	[illegible]	.80276	.98167	.99359	.99525	.99587	.96155
ALL	AVG SP D	1.33722	.63722	.40495	.70591	2.35223	2.91375	1.24174
	AVG RESP	.93477	.85024	.95214	.92802	.80113	.76157	.82964

MINIMUM BIAS COMBINATION DESIGN: 6 RADIAL AND 7 INNER VERTICES R2/R1= .595

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.05941	[illegible]	.12599	.16320	.20469	.11976
	AVG RESP	.97072	.97507	.96755	.94329	.91969	.88237	.94411
2	AVG SP D	.05173	.05577	.07110	.08761	.10394	.11997	.08352
	AVG RESP	.96995	.97058	.96330	.95162	.93669	.91893	.95184
3	AVG SP D	.34756	1.30534	.37615	.61316	.16516	.13830	.58445
	AVG RESP	[illegible]	.81101	.91935	.78330	.91698	.94304	.84463
4	AVG SP D	.11017	.13586	.20461	.32725	.50036	.77076	.34300
	AVG RESP	[illegible]	.92521	.91570	[illegible]	.69827	.54569	.80494
5	AVG SP D	1.25954	.83705	[illegible]	.92459	.83195	14.96005	3.39082
	AVG RESP	.70164	.70591	.70630	.70391	.71146	.71420	.70772
6	AVG SP D	[illegible]	.42209	[illegible]	3.24979	24.61333	6.98337	7.02238
	AVG RESP	.99399	.99542	.95608	.33969	-.08444	.25179	.57642
ALL	AVG SP D	[illegible]	.47091	[illegible]	1.72175	4.39966	3.86369	1.92399
	AVG RESP	[illegible]	.39754	[illegible]	.76229	.68311	.71017	.80495

MINIMUM BIAS COMBINATION DESIGN: 6 RADIAL AND 8 INNER VERTICES R2/R1= .604

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.07355	.06499	.07712	.10097	.12731	.15429	.09970
	AVG RESP	.95552	.97326	.97397	.96647	.95403	.93759	.96266
2	AVG SP D	.05699	.05487	.05024	.07023	.08200	.09509	.07124
	AVG RESP	[illegible]	.97199	.97041	.96522	.95735	.94731	.96339
3	AVG SP D	.65660	.33105	[illegible]	.29560	.91761	.34572	.90821
	AVG RESP	.75500	.83409	[illegible]	.84786	.82025	.90374	.81946
4	AVG SP D	.12218	[illegible]	.16450	.21923	.27754	.33592	.20796
	AVG RESP	[illegible]	.92205	[illegible]	.91944	.88997	.85587	.90104
5	AVG SP D	[illegible]	.21596	[illegible]	3.99774	.99102	.79739	1.40010
	AVG RESP	.70500	.71091	.71121	.71250	.71389	.71537	.71198
6	AVG SP D	[illegible]	.25940	.41861	.56303	.69011	.82915	.46357
	AVG RESP	[illegible]	.99519	[illegible]	.99571	.99432	.97965	.99089
ALL	AVG SP D	.52133	[illegible]	[illegible]	.65750	.51527	.42475	.52513
	AVG RESP	[illegible]	.90193	.90037	.99937	.88063	.87309	.89157

MINIMUM BIAS COMBINATION DESIGN: 6 RADIAL AND 9 INNER VERTICES R2/R1= .611

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	[illegible]	[illegible]	.09563	.12573	.15659	.09986
	AVG RESP	[illegible]	[illegible]	[illegible]	.96956	[illegible]	.93103	.96400
2	AVG SP D	[illegible]	.05554	[illegible]	.06701	.07974	.09441	.07037
	AVG RESP	[illegible]	.97317	[illegible]	.96486	.96096	.95031	.96549
3	AVG SP D	[illegible]	.53552	[illegible]	.55117	.25935	.47095	.55505
	AVG RESP	[illegible]	.84409	[illegible]	[illegible]	.87178	.92243	.84165
4	AVG SP D	[illegible]	.13473	.17912	.23157	.28560	.34997	.21640
	AVG RESP	.89555	.91473	.90875	.88469	.84746	.80076	.87499
5	AVG SP D	.87105	.79297	.35767	9.17930	.92394	.78091	2.25231
	AVG RESP	.71941	.71925	.71725	.71940	.71971	.72116	.71903
6	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	.51236	.62825	.34166
	AVG RESP	[illegible]	[illegible]	[illegible]	.99183	[illegible]	.97891	.99195
ALL	AVG SP D	[illegible]	.29527	.39967	1.75401	.30459	.41385	.59328
	AVG RESP	[illegible]	.90577	[illegible]	[illegible]	[illegible]	.86077	.89769

MINIMUM BIAS COMBINATION DESIGN: 6 RADIAL AND 10 INNER VERTICES R2/R1= .615

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SPD	.07354	.07845	.08595	.10521	.14159	.18925	.11347
	AVG RESP	.95900	.97388	.97149	.95490	.93267	.89551	.94910
2	AVG SPD	.07042	.05936	.06422	.07946	.09722	.11588	.08109
	AVG RESP	.96487	.97146	.96923	.96111	.94839	.93145	.95775
3	AVG SPD	.35031	2.27115	.33319	.29969	.34670	.20936	.62007
	AVG RESP	.81571	.94190	.90092	.84554	.87928	.59703	.85326
4	AVG SPD	.13366	.15313	.13051	.34255	.56609	.77783	.35681
	AVG RESP	.99371	.90973	.85204	.74491	.64752	.59980	.77962
5	AVG SPD	.55795	.79415	1.39087	1.17245	.79193	.85329	.95345
	AVG RESP	.72131	.72210	.72311	.72436	.72583	.72750	.72403
6	AVG SPD	.02512	.17959	.34991	.55122	1.54516	5.63435	1.41373
	AVG RESP	.99999	.99584	.99411	.97725	.89479	.35733	.87205
ALL	AVG SPD	.24513	.58931	.37594	.44176	.58812	1.29733	.58977
	AVG RESP	.92276	.90132	.90182	.86607	.83808	.73427	.85614

MINIMUM BIAS COMBINATION DESIGN: 7 RADIAL AND 5 INNER VERTICES R2/R1= .537

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SPD	.05175	.09325	.10153	.32953	.87563	4.62019	1.01962
	AVG RESP	.97715	.95394	.87963	.60342	.43035	.21506	.63149
2	AVG SPD	.05185	.07486	.11727	.15309	.21947	.32369	.15591
	AVG RESP	.97735	.95090	[illegible]	.32561	.71751	.59591	.62840
3	AVG SPD	[illegible]	.28444	.24177	1.02275	.54201	.35710	.47735
	AVG RESP	.94946	.37495	.88010	.96239	.82540	.77363	.84349
4	AVG SPD	.11374	1.73992	1.50067	5.95633	.67933	.41095	1.73385
	AVG RESP	.90935	.54034	.61452	.45945	.57895	.73730	.65690
5	AVG SPD	1.25175	1.66225	3.56321	4.06394	1.71068	1.27015	2.25566
	AVG RESP	.67333	.67247	.67163	.67030	.66999	.66920	.67124
6	AVG SPD	.02775	.17494	.13964	.22359	.26705	.31948	.20036
	AVG RESP	.99999	.99935	.99893	.99754	.99589	.99327	.99750
ALL	AVG SPD	.30297	.66928	.97825	1.95662	.71570	1.22093	.97396
	AVG RESP	.89719	.84550	.82463	.75156	.70302	.66406	.79150

MINIMUM BIAS COMBINATION DESIGN: 7 RADIAL AND 6 INNER VERTICES R2/R1= .563

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SPD	.05549	.07694	.12595	.23901	.31604	.53358	.21917
	AVG RESP	.97435	.96105	.91329	.83348	.70820	.59364	.83004
2	AVG SPD	.05555	.06296	.08922	.11255	.14795	.19545	.10965
	AVG RESP	.97490	.95751	.92723	.89359	.32352	.75619	.88696
3	AVG SPD	.78535	.32429	.13424	.43592	.13127	.10302	.36218
	AVG RESP	.81405	.82935	.77133	.94052	.86936	.85340	.83796
4	AVG SPD	.11291	.29572	.37279	3.15196	3.47505	1.51029	1.58628
	AVG RESP	.91058	.79515	.82210	.46545	.35151	.43137	.59781
5	AVG SPD	.65019	.39795	1.31242	1.49541	71.67945	1.49197	12.87812
	AVG RESP	.63392	.63655	.68450	.68185	.67934	.67675	.68297
6	AVG SPD	.02773	.27531	.24430	.23951	.23724	.23710	.21014
	AVG RESP	.99933	.99544	.99957	.99964	.99433	.99423	.99867
ALL	AVG SPD	.27151	.32094	.46231	.93391	12.66450	.65424	2.56076
	AVG RESP	.89190	.87136	.82363	.78369	.74343	.71935	.80574

MINIMUM BIAS COMBINATION DESIGN: 7 RADIAL AND 7 INNER VERTICES R2/R1= .509

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SPD	.05439	.06365	.10416	.15472	.22640	.33547	.15720
	AVG RESP	.97551	.95402	.93511	.87997	.79262	.69575	.87235
2	AVG SPD	.05513	.06527	.07575	.09744	.12412	.15739	.09467
	AVG RESP	.97561	.96042	.93507	.90107	.85498	.79990	.90468
3	AVG SPD	5.51945	.60594	4.93739	.15403	.11890	.10437	1.98435
	AVG RESP	.78434	.58319	.78459	.91294	.91406	.87559	.82323
4	AVG SPD	.11149	.23556	.70541	.35331	1.74919	13.01784	2.79492
	AVG RESP	.90099	.83159	.65341	.59555	.40978	.35629	.63298
5	AVG SPD	.93524	.90759	.90490	.89456	.90664	.93295	.91196
	AVG RESP	.62134	.68798	[illegible]	.68135	.67900	.67457	.69292
6	AVG SPD	.02735	.20135	.18331	.23519	.23265	.23194	.20470
	AVG RESP	.99999	.99559	.99973	.99472	.99462	.99052	.99886
ALL	AVG SPD	1.29415	.35015	1.06504	.41067	.55965	2.46531	1.02530
	AVG RESP	.85444	.85595	.83359	.83159	.77301	.73194	.81917

MINIMUM BIAS COMBINATION DESIGN: 7 RADIAL AND 8 INNER VERTICES R2/R1= .493

SURFACE\ERR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SPD	.05399	.09915	.10935	.15704	.23347	.35992	.16710
	AVG RESP	.97491	.95172	.93035	.93560	.79039	.67079	.87189
2	AVG SPD	.05433	.06394	.07904	.09603	.11593	.14399	.09468
	AVG RESP	.97491	.95550	.93305	.91143	.87519	.83067	.91430
3	AVG SPD	.61344	.40215	2.33743	.33417	.34103	.63950	.73902
	AVG RESP	.83127	.82433	.80415	.79645	.77624	.76495	.79981
4	AVG SPD	.12328	.25112	20.02633	1.14900	1.44050	3.38524	4.39591
	AVG RESP	.90413	.81679	.50954	.56635	.47246	.45753	.62921
5	AVG SPD	.35613	.94408	1.39671	1.41625	2.87903	3.83653	1.83946
	AVG RESP	.70444	.70142	.69835	.69523	.69207	.69887	.69673
6	AVG SPD	.02775	.45057	.22219	.29135	.27570	.27034	.27383
	AVG RESP	.99994	.99514	.99645	.99637	.99657	.99420	.99697
ALL	AVG SPD	.21354	.36617	3.99349	.59904	.88159	1.43925	1.25133
	AVG RESP	.89561	.87723	.81415	.80642	.76616	.73635	.81799

MINIMUM BIAS COMBINATION DESIGN: 7 RADIAL AND [illegible] INNER VERTICES R2/R1= .502

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.95683	[illegible]	[illegible]	[illegible]	.61722	.23906
	AVG RESP	[illegible]	.96100	[illegible]	[illegible]	[illegible]	.57471	.83491
2	AVG SP D	[illegible]	.07177	[illegible]	[illegible]	[illegible]	.17525	.10723
	AVG RESP	.96919	.95562	[illegible]	[illegible]	[illegible]	.73337	.90063
3	AVG SP D	[illegible]	.44903	[illegible]	[illegible]	[illegible]	.85388	.59912
	AVG RESP	[illegible]	.80443	[illegible]	[illegible]	.76726	.71762	.78074
4	AVG SP D	[illegible]	.31794	[illegible]	[illegible]	[illegible]	.80595	1.33031
	AVG RESP	[illegible]	.75265	[illegible]	[illegible]	[illegible]	.62631	.65476
5	AVG SP D	[illegible]	1.13930	[illegible]	[illegible]	[illegible]	.91541	1.43379
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	.59934	.69636	.70370
6	AVG SP D	.02775	.41739	[illegible]	[illegible]	.24179	.23753	.24271
	AVG RESP	.99399	.99375	[illegible]	.99611	.99562	.99552	.99623
ALL	AVG SP D	[illegible]	.41356	[illegible]	[illegible]	1.10183	[illegible]	.64904
	AVG RESP	[illegible]	.86245	[illegible]	[illegible]	[illegible]	.73398	.81183

MINIMUM BIAS COMBINATION DESIGN: 7 RADIAL AND 10 INNER VERTICES R2/R1= [illegible]

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.09978	[illegible]	[illegible]	.60255	[illegible]	1.16088
	AVG RESP	[illegible]	.95523	[illegible]	[illegible]	[illegible]	[illegible]	.74295
2	AVG SP D	[illegible]	.08025	[illegible]	[illegible]	[illegible]	.25723	.13149
	AVG RESP	[illegible]	.94963	[illegible]	[illegible]	[illegible]	[illegible]	.86699
3	AVG SP D	[illegible]	.73119	.42172	.71298	[illegible]	.58106	.59655
	AVG RESP	[illegible]	.78972	.77619	.73701	.72744	.69349	.76225
4	AVG SP D	.13412	.50806	[illegible]	2.17774	.63546	.35984	.82118
	AVG RESP	[illegible]	.62152	[illegible]	.58557	.68661	.84059	.69297
5	AVG SP D	[illegible]	1.15955	[illegible]	5.13715	1.45955	1.07181	1.95058
	AVG RESP	.71579	.71415	[illegible]	.70478	.70604	.70327	.71009
6	AVG SP D	.02777	.26517	.20745	.19735	.19604	.19747	.18187
	AVG RESP	[illegible]	.99785	[illegible]	[illegible]	.99727	[illegible]	.99796
ALL	AVG SP D	[illegible]	.47551	[illegible]	[illegible]	.60608	1.36779	.80709
	AVG RESP	[illegible]	.83766	[illegible]	.77935	.74522	.70578	.79554

MINIMUM BIAS COMBINATION DESIGN: 8 RADIAL AND 5 INNER VERTICES R2/R1= .513

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.07929	.13174	.22326	.41775	1.37337	.37891
	AVG RESP	[illegible]	.95163	[illegible]	[illegible]	[illegible]	[illegible]	.76140
2	AVG SP D	[illegible]	.07330	.10931	.16430	.25446	.44212	.18198
	AVG RESP	[illegible]	.95066	[illegible]	[illegible]	.67710	.54327	.80792
3	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	.35462	2.92959	.90935
	AVG RESP	[illegible]	.89127	[illegible]	.85735	.76124	.63127	.80992
4	AVG SP D	[illegible]	1.39437	[illegible]	1.39325	[illegible]	.73475	5.39085
	AVG RESP	[illegible]	.67397	[illegible]	[illegible]	[illegible]	.49419	.60384
5	AVG SP D	1.45377	3.39113	[illegible]	.97376	.93457	[illegible]	1.48397
	AVG RESP	[illegible]	.66267	[illegible]	[illegible]	.64526	.63951	.65397
6	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	.16097	[illegible]	.14008
	AVG RESP	[illegible]	.99946	[illegible]	.99948	.99942	[illegible]	.99953
ALL	AVG SP D	[illegible]	[illegible]	[illegible]	.53491	5.03161	1.10313	1.41402
	AVG RESP	[illegible]	.85485	[illegible]	.75913	.67636	.61948	.77260

MINIMUM BIAS COMBINATION DESIGN: 8 RADIAL AND 6 INNER VERTICES R2/R1= .545

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.09412	[illegible]	.19783	.31678	.60417	.23113
	AVG RESP	[illegible]	[illegible]	[illegible]	.79113	.64552	.49161	.78924
2	AVG SP D	.05275	.08334	.12714	.19795	.30993	.57932	.22424
	AVG RESP	[illegible]	.94322	[illegible]	.79576	.60221	.50604	.79689
3	AVG SP D	[illegible]	.25069	[illegible]	.46313	.61039	1.61020	.55057
	AVG RESP	[illegible]	.89395	[illegible]	.81969	.71160	.61255	.81477
4	AVG SP D	[illegible]	.30462	[illegible]	1.09271	15.36492	[illegible]	4.80559
	AVG RESP	.91717	.75469	[illegible]	[illegible]	[illegible]	[illegible]	.60598
5	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	.93137	[illegible]	1.26057
	AVG RESP	[illegible]	.67571	[illegible]	[illegible]	[illegible]	[illegible]	.66536
6	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	.56793	[illegible]	[illegible]
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	.91633	.77189	.94650
ALL	AVG SP D	[illegible]	[illegible]	[illegible]	.53966	3.01705	1.39529	1.31297
	AVG RESP	[illegible]	.87005	[illegible]	.75635	[illegible]	.58260	.76996

MINIMUM BIAS COMBINATION DESIGN: 8 RADIAL AND 7 INNER VERTICES R2/R1= .566

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	.33595	[illegible]	[illegible]
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	AVG SP D	[illegible]	[illegible]	[illegible]	.16257	.22575	[illegible]	.16106
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	.79154	.63111	[illegible]
3	AVG SP D	[illegible]	[illegible]	[illegible]	.32197	[illegible]	2.15396	[illegible]
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.31170
	AVG RESP	[illegible]	.74285	[illegible]	[illegible]	[illegible]	.62947	.63780
5	AVG SP D	[illegible]	.92377	[illegible]	[illegible]	1.31961	[illegible]	[illegible]
	AVG RESP	[illegible]	.66413	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.60367	[illegible]
ALL	AVG SP D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.94171
	AVG RESP	[illegible]	.87469	[illegible]	.77355	[illegible]	.61271	.79117

MINIMUM BIAS COMBINATION DESIGN: [illegible] RADIAL AND [illegible] INNER VERTICES R2/R1= .681

SURFACENERGY OF [illegible]		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SPD	.05555	.09219	[illegible]	[illegible]	[illegible]1735	1.26516	.35768
	AVG RESP	.97292	.94700	[illegible]	[illegible]	[illegible]51	.39629	.76532
2	AVG SPD	[illegible]	.08355	.11321	.154[illegible]	[illegible]043	.29311	.15265
	AVG RESP	[illegible]	.94579	[illegible]	[illegible]	.75897	.62631	.83694
3	AVG SPD	.17[illegible]	.14775	[illegible]	.76228	.46759	.38337	.45444
	AVG RESP	.92729	.95577	[illegible]	[illegible]	.90024	.72362	.86716
4	AVG SPD	.11[illegible]	.39702	[illegible]	[illegible]	.31937	.45299	.91149
	AVG RESP	[illegible]	.71491	[illegible]	[illegible]	[illegible]91	.75711	.66764
5	AVG SPD	[illegible]	.85362	[illegible]	1.07176	1.66117	4.90577	1.69479
	AVG RESP	.59720	.69156	[illegible]577	[illegible]	[illegible]7422	.66541	.68285
6	AVG SPD	.02776	.15001	[illegible]	[illegible]	[illegible]	.53559	.25813
	AVG RESP	[illegible]	.99919	[illegible]	[illegible]	.98343	.94978	.98740
ALL	AVG SPD	.21[illegible]	.29316	[illegible]	[illegible]	.65479	1.38928	.63986
	AVG RESP	[illegible]	.87[illegible]	[illegible]	.77[illegible]	.72905	.68724	.80122

MINIMUM BIAS COMBINATION DESIGN: [illegible] RADIAL AND [illegible] INNER VERTICES R2/R1= .592

SURFACENERGY OF [illegible]		[illegible]	0.03	[illegible]	[illegible]	[illegible].12	0.15	AVERAGE
1	AVG SPD	[illegible]364	.10245	[illegible]	[illegible]	[illegible]	10.62[illegible]	1.98745
	AVG RESP	[illegible]	.93[illegible]	[illegible]	[illegible]	[illegible]31	.26541	.70147
2	AVG SPD	[illegible]57	.09324	[illegible]	[illegible]	.27222	.41[illegible]	.19492
	AVG RESP	.97125	.93[illegible]97	[illegible]	[illegible]	[illegible]	.51517	.79073
3	AVG SPD	.13[illegible]	.24[illegible]53	[illegible]	[illegible]	[illegible]	.71[illegible]	.32625
	AVG RESP	[illegible]	.95[illegible]	[illegible]	.88445	[illegible]0722	.70[illegible]7	.86603
4	AVG SPD	.11[illegible]	.97585	1.[illegible]	[illegible].18791	.49212	.37439	1.24337
	AVG RESP	.90597	.62533	[illegible]	[illegible]	.72549	.80[illegible]	.67349
5	AVG SPD	.86597	.83595	[illegible]	1.26[illegible]	6.[illegible]842	1.15473	1.88389
	AVG RESP	.70557	.67[illegible]25	[illegible]	[illegible]	[illegible]	.57726	.69036
6	AVG SPD	.02777	.15937	.21[illegible]	.35[illegible]15	.91[illegible]	6.43[illegible]46	1.35172
	AVG RESP	.99[illegible]	.99919	[illegible]	[illegible]931	.78335	.66398	.90368
ALL	AVG SPD	.21153	.40259	[illegible]	1.[illegible]105	1.49494	3.28756	1.16460
	AVG RESP	.91[illegible]	.35929	[illegible]	.75580	.63536	.60573	.77079

MINIMUM BIAS COMBINATION DESIGN: [illegible] RADIAL AND 10 INNER VERTICES R2/R1= .600

SURFACENERGY OF [illegible]		0.00	0.03	[illegible]	[illegible]	0.12	0.15	AVERAGE
1	AVG SPD	.03537	.10232	[illegible]	.2913[illegible]	.57724	6.11395	1.23603
	AVG RESP	.95972	.93[illegible]91	[illegible]	.79[illegible]	[illegible]	.28519	.70579
2	AVG SPD	.06529	.08959	[illegible]	[illegible]	[illegible]	.34752	.17950
	AVG RESP	.96972	.93925	[illegible]8537	[illegible]	[illegible]	.55603	.80545
3	AVG SPD	.14114	.27377	[illegible]	.26479	.46972	.47174	.30703
	AVG RESP	.95579	.93749	[illegible]	.85328	[illegible]	.77489	.87514
4	AVG SPD	.12[illegible]	.75[illegible]	1.[illegible]	5.59[illegible]	[illegible]	.35767	1.14231
	AVG RESP	.95254	[illegible]	[illegible]	[illegible]	[illegible]	.93375	.67850
5	AVG SPD	.99738	[illegible]	[illegible]	[illegible]	[illegible]	1.23220	.93607
	AVG RESP	.70935	.70456	[illegible]	[illegible]	[illegible]027	.68551	.69743
6	AVG SPD	.02777	.15744	[illegible]	.19322	.24405	.30732	.18377
	AVG RESP	.99399	.99945	[illegible]	.99730	[illegible]	.98891	.99647
ALL	AVG SPD	.21325	.37[illegible]	[illegible]	[illegible]	[illegible]	1.47173	.66262
	AVG RESP	.91735	.85545	[illegible]	[illegible]	.72995	.68737	.79313

MINIMUM BIAS COMBINATION DESIGN: [illegible] RADIAL AND [illegible] INNER VERTICES R2/R1= .489

SURFACENERGY OF [illegible]		[illegible]	0.03	[illegible]	[illegible]	0.12	0.15	AVERAGE
1	AVG SPD	[illegible]	.07765	.12525	.29984	.34519	.79[illegible]	.26469
	AVG RESP	[illegible]	.95306	[illegible]	.79996	.62[illegible]1	.45958	.78349
2	AVG SPD	[illegible]	.09109	[illegible]	.53705	25.[illegible]	1.02[illegible]	4.61554
	AVG RESP	[illegible]	.95512	[illegible]	.57381	[illegible]7473	[illegible]	.64460
3	AVG SPD	.01937	[illegible]	[illegible]	.29965	.19635	.16717	.27543
	AVG RESP	.93415	.91[illegible]	[illegible]	.99192	.94671	.95862	.89932
4	AVG SPD	.10[illegible]	.17171	[illegible]	.79297	1.25661	12.75146	2.57814
	AVG RESP	.92[illegible]77	.84[illegible]7	[illegible]	.52921	.46887	.40972	.63238
5	AVG SPD	1.34011	1.03452	[illegible]	[illegible]	1.19734	2.25159	2.85178
	AVG RESP	[illegible]	.65[illegible]17	[illegible]	[illegible]	.64013	.63407	.64916
6	AVG SPD	.02795	[illegible]	[illegible]	1.41[illegible]	[illegible]	.35107	.55943
	AVG RESP	.99493	[illegible]	[illegible]	[illegible]	.92057	.98698	.93769
ALL	AVG SPD	.30[illegible]	.29772	[illegible]	2.14929	4.49[illegible]	2.89077	1.85734
	AVG RESP	[illegible]	.85769	[illegible]	.72179	.61338	.64203	.75777

MINIMUM BIAS COMBINATION DESIGN: [illegible] RADIAL AND [illegible] INNER VERTICES R2/R1= .525

SURFACENERGY OF [illegible]		0.00	0.03	[illegible]	[illegible]	0.12	0.15	AVERAGE
1	AVG SPD	[illegible]	.07[illegible]	[illegible]	.17[illegible]	[illegible]404	.39377	.17794
	AVG RESP	.97[illegible]	[illegible]	[illegible]	[illegible]	.73377	.59123	.83544
2	AVG SPD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26.38183	4.52618
	AVG RESP	[illegible]	[illegible]	[illegible]	.75653	[illegible]	.05[illegible]	.68353
3	AVG SPD	[illegible]	[illegible]	[illegible]	.61619	[illegible]	.20421	.39702
	AVG RESP	[illegible]	[illegible]	[illegible]	.71901	[illegible]	.94[illegible]	.83913
4	AVG SPD	[illegible]	.171[illegible]	[illegible]	[illegible]	.74535	1.11237	.90941
	AVG RESP	.92961	.34952	[illegible]	[illegible]	.50182	.44045	.64778
5	AVG SPD	.97[illegible]	8.82793	1.[illegible]	[illegible]	1.59091	1.33179	2.44434
	AVG RESP	[illegible]	.57017	[illegible]	[illegible]	[illegible]	.64649	.66130
6	AVG SPD	[illegible]	[illegible]	[illegible]	[illegible]	.51113	[illegible]	[illegible]
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.94875
ALL	AVG SPD	[illegible]1[illegible]72	1.[illegible]	[illegible]	1.23[illegible]	[illegible]113	[illegible]	1.55794
	AVG RESP	[illegible]	[illegible]	[illegible]	.73[illegible]	[illegible]	[illegible]	.76[illegible]2

MINIMUM BIAS COMBINATION DESIGN: [illegible] RADIAL AND [illegible] INNER VERTICES R2/R1= [illegible]

SURFACE ERROR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	[illegible]	[illegible]	.153[illegible]	.21[illegible]26	.30[illegible]	.15997
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]	.75[illegible]	.64[illegible]	.99990
2	AVG SP D	[illegible]	.09961	.10451	.29612	.38362	2.54691	.56097
	AVG RESP	[illegible]	.85379	[illegible]	.79131	.59339	.29913	.75980
3	AVG SP D	[illegible]	12.79955	2.[illegible]602	[illegible]113	.29962	.22732	2.93740
	AVG RESP	[illegible]	.87749	.72513	.77351	[illegible]	.92913	.82515
4	AVG SP D	.1[illegible]42	.17313	.90192	[illegible]	.91584	2.15099	.82992
	AVG RESP	[illegible]	.83720	.84228	[illegible]	.69959	.42555	.64306
5	AVG SP D	[illegible]	1.28505	1.[illegible]	[illegible]	.37975	2.03069	1.26696
	AVG RESP	[illegible]97	.57[illegible]	[illegible]	.66712	[illegible]	.65612	[illegible]97
6	AVG SP D	[illegible]	.193[illegible]	[illegible]	11.[illegible]	1.47752	.59119	2.27356
	AVG RESP	.99999	.99355	[illegible]	[illegible]	[illegible]	.95499	.88839
ALL	AVG SP D	.27652	[illegible].43988	[illegible]	2.36281	.71241	1.26718	1.32[illegible]63
	AVG RESP	.84097	.88334	[illegible]0658	.67794	.71062	.65190	.77139

MINIMUM BIAS COMBINATION DESIGN: 9 RADIAL AND [illegible] INNER VERTICES R2/R1= .568

SURFACE ERROR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]751	.09067	.15546	[illegible]	.29475	.45467	.20690
	AVG RESP	.97[illegible]	.99377	[illegible]8735	.791[illegible]	.64931	.48670	.79890
2	AVG SP D	[illegible]731	.10265	[illegible]	[illegible]	1.79476	89.92946	15.24140
	AVG RESP	.97[illegible]	.99446	[illegible]	.55477	.[illegible]1266	.12771	.64537
3	AVG SP D	.27[illegible]	.42269	[illegible]	.25354	.17470	.15405	.28390
	AVG RESP	[illegible]713	.87410	[illegible]6031	.90[illegible]	.95163	.95690	.39502
4	AVG SP D	[illegible]	.20765	1.17799	[illegible]	1.25[illegible]	4.92396	1.35172
	AVG RESP	.91[illegible]14	.80197	[illegible]6020	[illegible]	.45384	.35151	.58532
5	AVG SP D	.8[illegible]25	1.13353	1.[illegible]25	[illegible]917	1.16591	1.41094	1.12568
	AVG RESP	[illegible]	.68570	[illegible]	.67[illegible]	.67087	.66623	.67833
6	AVG SP D	.12778	.19341	[illegible]1315	1.[illegible]32	.68869	.36689	.69079
	AVG RESP	.99999	.99305	[illegible]3171	[illegible]5131	.91670	.98551	.92963
ALL	AVG SP D	.23208	.36346	[illegible]1467	.83290	[illegible]9311	15.67416	3.13506
	AVG RESP	.90539	.87551	.78837	.70312	.64984	.59744	.75393

MINIMUM BIAS COMBINATION DESIGN: 9 RADIAL AND 9 INNER VERTICES R2/R1= .581

SURFACE ERROR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]42	.09465	.12969	[illegible]	.23795	.33636	.17004
	AVG RESP	.97992	.94588	[illegible]1013	[illegible]	.71944	.58913	.82493
2	AVG SP D	[illegible]43	.09765	.15947	[illegible]	[illegible]975	9.80784	1.82778
	AVG RESP	.97092	.94[illegible]	[illegible]8748	.75541	.51582	.26172	.72333
3	AVG SP D	.22257	.28175	[illegible]	.95824	.20356	.15949	.40229
	AVG RESP	[illegible]126	.88503	.73054	.93321	[illegible]	.95963	.98297
4	AVG SP D	.11[illegible]	.19433	1.[illegible]6293	2[illegible]	2.[illegible]	11.22797	6.81492
	AVG RESP	.99477	.81552	[illegible]575	[illegible]	.81266	.37441	.69086
5	AVG SP D	[illegible]705	.93112	9.[illegible]7041	[illegible]	[illegible]	1.18496	2.65779
	AVG RESP	[illegible]719	.59[illegible]	[illegible]8775	.68322	.67883	.67459	[illegible]8567
6	AVG SP D	.12777	.17[illegible]	[illegible]7497	1.18376	2.91211	.87579	.89164
	AVG RESP	[illegible]	.99491	[illegible]9014	.61015	[illegible]	.92971	.88906
ALL	AVG SP D	.22[illegible]7	.29533	2.17575	4.[illegible]	[illegible]	[illegible].93374	2.09573
	AVG RESP	[illegible]	.88079	[illegible]1355	[illegible]	.677[illegible]	.62903	.76762

MINIMUM BIAS COMBINATION DESIGN: 9 RADIAL AND 10 INNER VERTICES R2/R1= .591

SURFACE ERROR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]313	.09132	.10393	.132[illegible]3	.17079	.22342	.12925
	AVG RESP	[illegible]7145	.94905	[illegible]1660	.86615	.79460	.70153	.86669
2	AVG SP D	[illegible]19	.03729	[illegible]2323	.17971	.27115	.45239	.19598
	AVG RESP	.97143	.95069	[illegible]1131	.89007	.72431	.57337	.82953
3	AVG SP D	[illegible]	.23909	[illegible]8256	.60014	.48032	.41669	.42155
	AVG RESP	[illegible]7577	.90[illegible]12	[illegible]	.77177	.77235	.79314	.82531
4	AVG SP D	.11[illegible]94	.17594	[illegible]128	.9157[illegible]	.95912	1.16979	.59810
	AVG RESP	[illegible]	.3397[illegible]	.76[illegible]	.57[illegible]	.47365	.40357	.65068
5	AVG SP D	[illegible]	[illegible]	1.[illegible]	27.[illegible]	1.07[illegible]	.83047	5.43969
	AVG RESP	.7[illegible]	.69912	[illegible]	[illegible]	.65430	.57937	.69124
6	AVG SP D	[illegible]777	.15[illegible]	.10411	[illegible]	.21163	.25315	.16716
	AVG RESP	[illegible]	[illegible]	[illegible]	[illegible]41	[illegible]	.99392	.99797
ALL	AVG SP D	.24247	.25919	[illegible]6012	[illegible]	.51163	.55579	1.15945
	AVG RESP	[illegible]35	.89107	[illegible]6151	.7997[illegible]	.74102	.69173	.81907

MINIMUM BIAS COMBINATION DESIGN: 10 RADIAL AND 5 INNER VERTICES R2/R1= .462

SURFACE ERROR ST DEV		0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.05[illegible]	[illegible]8393	.1[illegible]	.16735	.23121	.11691
	AVG RESP	[illegible]	.97473	[illegible]5645	[illegible]	.96946	.79429	.91661
2	AVG SP D	[illegible]31	[illegible]	[illegible]	.15[illegible]	.25545	.52239	.19319
	AVG RESP	[illegible]	.96835	[illegible]	[illegible]	.92340	.60191	.89128
3	AVG SP D	[illegible]	.05[illegible]2	[illegible]9232	1.[illegible]	3.99032	.65102	.93709
	AVG RESP	[illegible]	.48[illegible]	[illegible]4700	.49921	.30520	.68785	.70149
4	AVG SP D	.10174	.10110	.12049	.15919	.19927	.24122	.15984
	AVG RESP	.92[illegible]7	.90[illegible]	[illegible]7605	[illegible]	.79411	.74064	.84000
5	AVG SP D	4.50[illegible]26	1.39335	1.[illegible]3147	.97732	1.05293	1.45276	1.73577
	AVG RESP	.55[illegible]	.65[illegible]	[illegible]5272	[illegible]	.64487	.64075	.65962
6	AVG SP D	[illegible]2734	.50[illegible]	[illegible]	[illegible]	[illegible]	.27439	.35965
	AVG RESP	[illegible]	.97547	[illegible]	[illegible]	[illegible]	[illegible]	.99565
ALL	AVG SP D	[illegible]	.36[illegible]70	.20717	[illegible]101	.97755	.55[illegible]83	.59123
	AVG RESP	[illegible]351	.91413	[illegible]	.90255	.74987	.74442	.93743

MINIMUM BIAS COMBINATION DESIGN: 10 RADIAL AND [illegible] INNER VERTICES R2/R1= .505

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	[illegible]	.05769	.0[illegible]917	.11915	.16086	.21674	.11407
	AVG RESP	.97[illegible]	.97193	.[illegible]331	.9[illegible]77	.87038	.80036	.91607
2	AVG SP D	.0[illegible]81	.06204	.09542	.15776	.27095	.52858	.19359
	AVG RESP	.97963	.97955	.96562	.92271	.81668	.60914	.87391
3	AVG SP D	.01284	.07638	.46255	8.17[illegible]01	.46778	.31657	1.58585
	AVG RESP	.99556	.98599	.79263	.27682	.78285	.87759	.78524
4	AVG SP D	.10026	.09900	.11859	.14799	.18503	.23066	.14692
	AVG RESP	.92301	.90513	.[illegible]7362	.83454	.79142	.74730	.84584
5	AVG SP D	1.0[illegible]53	2.79579	1.41915	1.01[illegible]	.96942	1.09270	1.39550
	AVG RESP	.67087	.66741	.66387	.66024	.65651	.65267	.66193
6	AVG SP D	.02785	.79731	.51601	.31998	.27545	.25656	.36553
	AVG RESP	.99[illegible]	.93003	.[illegible]169	.99[illegible]	.99409	.99493	.98213
ALL	AVG SP D	.21087	.64853	.55182	1.65271	.38825	.44030	.63358
	AVG RESP	.92473	.90569	.87179	.76786	.81865	.79133	.84502

MINIMUM BIAS COMBINATION DESIGN: 10 RADIAL AND 7 INNER VERTICES R2/R1= .534

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05[illegible]	.05701	.[illegible]525	.16171	.24922	.41990	.17517
	AVG RESP	.97771	.95415	[illegible]	.86546	.75538	.60907	.85943
2	AVG SP D	.05[illegible]	.07920	.[illegible]172	.24973	.31697	3.33516	.80228
	AVG RESP	.97771	.97277	.9[illegible]	.89[illegible]	.37785	.21455	.71416
3	AVG SP D	.05352	.62120	5.6[illegible]998	.24295	.17563	.15275	1.12256
	AVG RESP	.95095	.76791	.[illegible]467	.91[illegible]	.95036	.95724	.86344
4	AVG SP D	.10221	.10669	.13584	.19233	.25034	.35171	.18985
	AVG RESP	.91929	.89099	.[illegible]4243	.79236	.71532	.64169	.79852
5	AVG SP D	.93540	1.74767	1.24055	.93693	1.04323	11.07538	2.83903
	AVG RESP	.67359	.67560	.67253	.66936	.66613	.66279	.67184
6	AVG SP D	.02781	4.49725	.[illegible]9443	.24125	.22517	.21801	.91732
	AVG RESP	.99999	.61477	.99468	.99[illegible]28	.99676	.99699	.93324
ALL	AVG SP D	.20363	1.18650	1.[illegible]3455	.34233	.47679	2.59240	1.00603
	AVG RESP	.92404	.81420	.[illegible]2387	.83949	.74364	.68039	.80510

MINIMUM BIAS COMBINATION DESIGN: 10 RADIAL AND 8 INNER VERTICES R2/R1= .554

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05449	.06463	.[illegible]773	.1357[illegible]	.19448	.28313	.13771
	AVG RESP	.97597	.96587	.[illegible]472	.89700	.82318	.71720	.88682
2	AVG SP D	.05449	.07654	.12172	.21235	.43405	1.99284	.49133
	AVG RESP	.97597	.97390	.95243	.[illegible]8051	.66729	.22385	.77897
3	AVG SP D	.31473	.37312	.60549	.31947	.18969	.15040	.40948
	AVG RESP	.80617	.85101	.81925	.87678	.94620	.95388	.87838
4	AVG SP D	.10512	.10289	.12571	.16218	.21117	.27865	.16429
	AVG RESP	.91590	.89342	.[illegible]5543	.807[illegible]	.75298	.69487	.81998
5	AVG SP D	.85332	1.05905	15.64283	1.11267	.92274	.98283	3.43408
	AVG RESP	.68342	.68280	.68011	.67735	.67452	.67162	.67863
6	AVG SP D	.02779	21.33121	.36854	.26475	.23720	.22519	3.82578
	AVG RESP	.99999	.58183	.99074	.99493	.99595	.99639	.92564
ALL	AVG SP D	.32332	3.91909	2.72684	.36537	.36499	.65217	1.40961
	AVG RESP	.89324	.82546	.87328	.85564	.81035	.71047	.82824

MINIMUM BIAS COMBINATION DESIGN: 10 RADIAL AND 9 INNER VERTICES R2/R1= .569

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05763	.05825	.[illegible]7478	.09803	.12601	.15876	.09558
	AVG RESP	.97434	.96940	.95685	.93628	.90647	.86596	.93489
2	AVG SP D	.05763	.06764	.[illegible]8913	.12629	.18681	.28636	.13564
	AVG RESP	.97434	.97651	.96894	.9[illegible]622	.89663	.79997	.92712
3	AVG SP D	.39073	1.15789	.[illegible]2932	11.33[illegible]	.89713	.24358	2.41506
	AVG RESP	.97517	.85559	.[illegible]7283	.72241	.73282	.[illegible]973	.82493
4	AVG SP D	.10843	.09516	.10942	.1333[illegible]	.16017	.18948	.13273
	AVG RESP	.91270	.90092	.[illegible]7725	.84027	.81615	.78244	.85529
5	AVG SP D	.85191	.89304	1.[illegible]6242	2.11811	1.21315	1.06360	1.30204
	AVG RESP	.69159	.68085	.[illegible]8607	.[illegible]8324	.68235	.67743	.68459
6	AVG SP D	.02773	.37715	1.33156	.38134	.30270	.27[illegible]61	.44986
	AVG RESP	.99[illegible]	.98385	.[illegible]7735	.9[illegible]776	.99229	.99384	.97351
ALL	AVG SP D	.25[illegible]	.44513	.[illegible]1534	[illegible]	.5[illegible]	.37540	.75532
	AVG RESP	.9[illegible]437	.89[illegible]	.[illegible]7323	.[illegible]8403	.83745	.83[illegible]89	.86689

MINIMUM BIAS COMBINATION DESIGN: 10 RADIAL AND 10 INNER VERTICES R2/R1= .581

SURFACE	NERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.05[illegible]42	.05640	.[illegible]7109	.09134	.11346	.13735	.08934
	AVG RESP	.97[illegible]92	.96434	.[illegible]	.9[illegible]239	.91999	.99127	.94246
2	AVG SP D	.05[illegible]42	.05541	.[illegible]9134	.11139	.15543	.21786	.11531
	AVG RESP	.97293	.97569	.[illegible]7095	.95335	.91[illegible]72	.85979	.94194
3	AVG SP D	.27553	.27273	.[illegible]5123	.99941	2.77228	.77564	.91147
	AVG RESP	.[illegible]591	.37755	.[illegible]551	.91561	.66243	.72794	.80382
4	AVG SP D	.11137	.09242	.10[illegible]01	.13129	.15268	.17526	.12342
	AVG RESP	[illegible]	.90115	[illegible]	.85611	.82972	.80743	.85328
5	AVG SP D	.85714	.85120	.[illegible]1733	1.13761	2.62083	1.91815	1.36704
	AVG RESP	.69713	.69406	.69083	.69766	.68440	.68109	.68921
6	AVG SP D	.02777	.34130	5.[illegible]777	.53001	.36026	.31323	.99536
	AVG RESP	[illegible]	.99259	.73306	.99362	.9999[illegible]	.991[illegible]	.99521
ALL	AVG SP D	.25217	.27779	[illegible]	.49351	1.0[illegible]12	.57[illegible]	.59516
	AVG RESP	[illegible]	.90199	.[illegible]5170	.87362	.93405	.82555	.86532

UNIFORM PRECISION CENTRAL COMPOSITE DESIGN

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.04798	.06549	.07742	.08695	.09496	.06820
	AVG RESP	.98842	.98579	.98106	.97779	.97019	.96421	.97758
2	AVG SP D	.03457	.04185	.05645	.07090	.08367	.09529	.06366
	AVG RESP	.99440	.99124	.98857	.98370	.97765	.97165	.98337
3	AVG SP D	.06091	.06753	.07597	.08401	.09194	.09997	.07992
	AVG RESP	.95691	.95583	.95161	.94764	.94345	.93957	.94968
4	AVG SP D	.11440	.09935	.10296	.11277	.12025	.12641	.11119
	AVG RESP	.93420	.94598	.94310	.93797	.93201	.92521	.93657
5	AVG SP D	1.04570	1.04482	1.04205	1.04036	1.03978	1.04034	1.04267
	AVG RESP	.63348	.63591	.63815	.64051	.64285	.64520	.63933
6	AVG SP D	.02328	.23516	.27373	5.94938	3.23287	1.19165	1.85701
	AVG RESP	.99498	.99360	.95902	.57443	.27917	.83558	.78796
ALL	AVG SP D	.22006	.25433	.31944	1.21097	.77591	.44144	.53711
	AVG RESP	.91756	.91705	.91525	.84334	.79089	.88440	.87908

ORTHOGONAL CENTRAL COMPOSITE DESIGN

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.05541	.07042	.11213	.15033	.30796	.12495
	AVG RESP	.98842	.98545	.97499	.94994	.88983	.75596	.92577
2	AVG SP D	.03457	.04313	.05953	.11603	.20273	.40183	.14964
	AVG RESP	.99440	.98743	.97939	.95426	.88403	.69675	.91504
3	AVG SP D	.06091	.05520	.10830	.44951	.82095	1.74755	.60977
	AVG RESP	.96091	.96014	.94806	.79579	.70966	.77488	.86924
4	AVG SP D	.11440	.14305	.54980	.45346	.42656	.49502	.35622
	AVG RESP	.93420	.90274	.80591	.76050	.76025	.69619	.80995
5	AVG SP D	1.04570	1.12385	1.36031	2.54971	2.65521	1.41758	1.69223
	AVG RESP	.63348	.63063	.62767	.62461	.62144	.61816	.62600
6	AVG SP D	.02328	.18411	3.07649	.43012	.30883	.27100	.71680
	AVG RESP	.99498	.99445	.68354	.97880	.98903	.99187	.93962
ALL	AVG SP D	.22006	.26912	.57281	.74201	.76577	.77383	.60727
	AVG RESP	.91756	.91014	.83659	.84382	.81905	.75745	.84744

MINIMUM BIAS CENTRAL COMPOSITE DESIGN

SURFACE	ERR ST DEV	0.00	0.03	0.06	0.09	0.12	0.15	AVERAGE
1	AVG SP D	.03443	.05073	.17996	3.09128	1.07653	.37592	.80364
	AVG RESP	.98842	.90556	.92013	.25972	.40555	.70396	.71056
2	AVG SP D	.03456	.06110	.16188	.65615	3.62677	.79314	.88893
	AVG RESP	.99440	.98017	.90996	.54328	.13015	.47425	.67104
3	AVG SP D	.06091	.07293	.17092	.41630	.41307	1.58562	.45314
	AVG RESP	.96090	.96159	.89524	.79956	.77157	.75186	.85514
4	AVG SP D	.11440	.33977	.33277	1.99502	.71739	.40207	.65940
	AVG RESP	.93420	.81437	.79558	.65761	.60681	.73003	.75677
5	AVG SP D	1.04559	1.06912	1.08873	1.11071	1.13432	1.15987	1.10174
	AVG RESP	.63350	.62956	.62559	.62157	.61753	.61345	.62353
6	AVG SP D	.02328	1.51592	.25613	.24264	.23035	.22479	.42135
	AVG RESP	.99498	.35459	.99212	.99549	.99631	.99567	.97319
ALL	AVG SP D	.22006	.51075	.37006	1.25218	1.19974	.75740	.71987
	AVG RESP	.91757	.87166	.85644	.64454	.58832	.71170	.76504

BIBLIOGRAPHY

Literature Cited

1. Box, G. E. P. and Draper, N. R. 1959. "A Basis for the Selection of a Response Surface Design," Journal of the American Statistical Association, 54, 622-654.

2. Box, G. E. P. and Draper, N. R. 1963. "Choice of Second Order Rotatable Designs," Biometrika, 50, 335-352.

3. Box, G. E. P. and Hunter, J. S. 1957. "Multi-factor Experimental Designs for Exploring Response Surfaces," Annals of Mathematical Statistics, 28, 195-241.

4. Box, G. E. P. and Wilson, K. B. 1951. "On the Experimental Attainment of Optimum Conditions," Journal of the Royal Statistical Society, Series B, 13, 1-45.

5. Brooks, S. H. 1959. "A Comparison of Maximum-Seeking Methods," Operations Research, 7, 430-457.

6. Evans, Daniel M., Jr. 1971. "The Use of Second Order Response Surface Designs in Digital Simulation," Masters Thesis, Georgia Institute of Technology, Atlanta, Georgia.

7. Montgomery, Douglas C. and Evans, Daniel M., Jr. 1972. "Second Order Response Surface Designs in Digital Simulation," Paper presented to the 41st National ORSA Meeting, New Orleans, Louisiana, April, 1972.

8. Myers, Raymond H. 1971. Response Surface Methodology. Allyn and Bacon, Inc., Boston, Massachusetts.

Other References

Bose, R. C. and Carter, R. L. 1959. "Complex Representation in the Construction of Rotatable Designs," Annals of Mathematical Statistics, 30, 771-780.

Box, G. E. P. 1952. "Multifactor Designs of First Order," Biometrika, 39, 49-57.

BIBLIOGRAPHY (Continued)

Box, G. E. P. 1954. "The Exploration and Exploitation of Response Surfaces: Some General Considerations and Examples," Biometrics, 10, 16-60.

__________ 1957. "Use of Statistical Methods in the Elucidation of Basic Mechanisms," Bulletin of the Institute of International Statistics, 36, III, 215-225.

Box, G. E. P. and Behnkin, D. W. 1960. "Simplex-Sum Designs: A Class of Second Order Rotatable Designs Derivable from Those of First Order," Annals of Mathematical Statistics, 31, 838-864.

____________________. 1960. "Some New Three Level Designs for the Study of Quantitative Variables," Technometrics, 2, 455-474.

Box, G. E. P. and Hunter, J. S. 1959. "Second Order Rotatable Designs in Three Dimensions," Annals of Mathematical Statistics, 30, 1097-1112.

Box, G. E. P. and Hunter, William G. 1965. "The Experimental Study of Physical Mechanisms," Technometrics, 7, 23-42.

Box, G. E. P. and Youle, P. V. 1955. "The Exploration and Exploitation of Response Surfaces: An Example of the Link Between the Fitted Surface and the Basic Mechanism of the System," Biometrics, 11, 287-323.

Cochran, W. G. and Cox, G. M. 1957. Experimental Designs. John Wiley and Sons, Inc., New York.

Davies, O. L. 1960. Design and Analysis of Industrial Experiments, Hafner Publishing Co., New York.

Draper, N. R. and Herzberg, A. 1968. "Further Second Order Rotatable Designs," Annals of Mathematical Statistics, 39, 1995-2001.

Graybill, Franklin A. 1961. An Introduction to Linear Statistical Models, McGraw-Hill, New York.

Hill, William J. and Hunter, William G. 1966. "A Review of Response Surface Methodology: A Literature Survey," Technometrics, 8, 571-590.

Hotelling, H. 1941. "Experimental Determination of the Maximum of a Function," Annals of Mathematical Statistics, 12, 20-45.

Spendley, W., Hext, G. R., and Himsworth, F. R. 1962. "Sequential Application of Simple Designs in Optimisation and Evolutionary Operation," Technometrics, 4, 441-461.

BIBLIOGRAPHY (Concluded)

Wilde, Douglas J. 1964. Optimum Seeking Methods, Prentice-Hall, Englewood Cliffs, New Jersey.